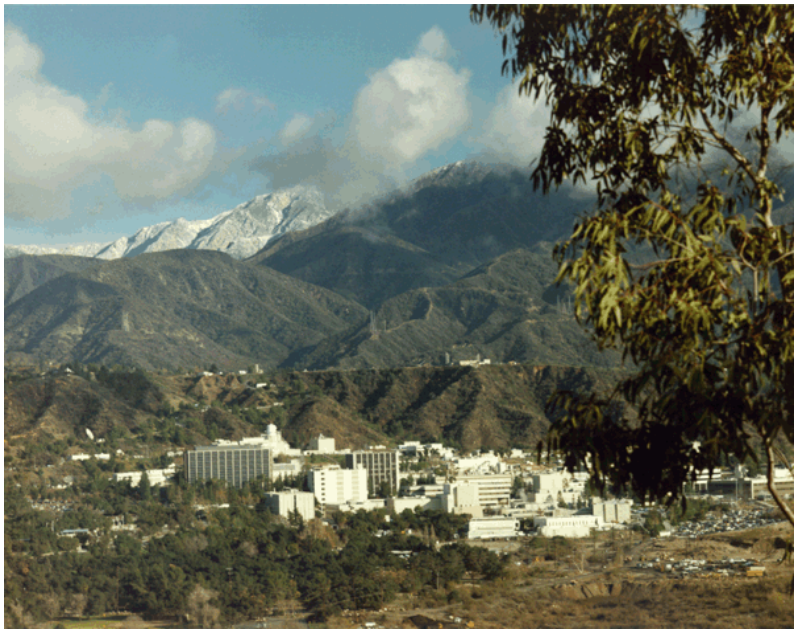
FINAL

INTERIM RECORD OF DECISION FOR OPERABLE UNIT 3 OFF-FACILITY GROUNDWATER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY
PASADENA, CALIFORNIA

EPA ID# CA9800013030



PREPARED FOR:

National Aeronautics and Space Administration
Management Office, Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109

Part I: DECLARATION

Site Name and Location

SITE NAME:	Jet Propulsion Laboratory (JPL)
EPA ID NUMBER:	CA9800013030; Federal Facility Agreement Docket Number 1998-27
LOCATION:	4800 Oak Grove, Pasadena, California
SITE TYPE:	Federal facility; Government-owned, contractor-operated
LEAD AGENCY:	National Aeronautics and Space Administration (NASA)
SUPPORTING AGENCIES:	U.S. Environmental Protection Agency (EPA), Region IX; State of California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC); and California Regional Water Quality Control Board (RWQCB), Los Angeles Region
OPERABLE UNIT:	Operable Unit 3 (OU-3), Off-Facility Groundwater

Statement of Basis and Purpose

This document is published as an Interim Record of Decision (ROD) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 United States Code (USC) § 9601 et seq. NASA prepared an Interim ROD because a response action is needed in the near term to prevent further migration of chemicals. This Interim ROD will be followed by a final ROD addressing both on-facility and off-facility groundwater.

This decision document presents the response action selected by NASA and the supporting agencies (EPA, DTSC, and RWQCB) for cleaning up off-facility groundwater (OU-3) at JPL. The response action was selected in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300.400 et seq. and California Health and Safety Code (HSC) § 25356.1. The response action was selected based upon information in the Administrative Record.

Assessment of the Site

The response action selected in this Interim ROD is necessary to remove target chemicals from the aquifer being used by the local community (Lincoln Avenue Water Company [LAWC] and the City of Pasadena) for drinking water, as well as to protect the environment from the additional migration of chemicals in groundwater outside the JPL fence line.

Description of the Selected Remedy

In October 1992, JPL was placed on the National Priorities List (NPL) and, therefore, is subject to the provisions of CERCLA to facilitate investigation and cleanup. The JPL site has been divided into three Operable Units (OUs). OU-1 addresses on-facility groundwater at JPL; OU-2 addresses on-facility vadose zone soil at JPL; and OU-3 addresses off-facility groundwater adjacent to the JPL property. This decision document addresses OU-3, off-facility groundwater at JPL.

To address chemicals in off-facility groundwater, NASA will fund removal of perchlorate and volatile organic compounds (VOCs) from the aquifer at four City of Pasadena drinking water wells by constructing a treatment facility to treat pumped groundwater. In addition, NASA will continue funding a treatment plant to remove perchlorate and VOCs from two LAWC wells. Groundwater will be pumped from multiple wells and treated at two centralized locations prior to use by City of Pasadena and LAWC customers. This combined alternative (i.e., the two centralized treatment systems) is preferred by NASA because it removes target chemicals from the groundwater in an aquifer being used by the local community for drinking water. In addition, centralized treatment will provide an additional level of hydraulic control to prevent the migration of chemical mass in groundwater.

In this remedy, NASA will directly administer some of the work associated with siting the new City of Pasadena treatment system. NASA also will provide some technical support to the City for the permitting process. The City of Pasadena is required by its own ordinances to go through several permitting processes, some of which include public review. NASA will provide funds to the City of Pasadena to lease treatment equipment and operate the system. Groundwater from four City of Pasadena drinking water wells – Arroyo Well, Well 52, Windsor Well, and Ventura Well – will be treated using a liquid-phase granular activated carbon (LGAC) system to remove VOCs, and an ion exchange system to remove perchlorate. The system is proposed to be located on City-owned land adjacent to the Windsor Well and Windsor Reservoir. NASA will also continue to fund the existing LGAC and ion exchange treatment system at LAWC, as well as continue groundwater monitoring activities in OU-3, which are currently conducted on a quarterly basis.

Statutory Determinations

This response action is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed; it complies with those federal and state requirements that are applicable or relevant and appropriate for this limited-scope action, and is cost-effective. Although this response action is not intended to fully address

the statutory mandate for permanence and treatment to the maximum extent practicable, this response action does utilize treatment and will support the final remedy.

A five-year review will be conducted in 2007 and then every five years thereafter until the JPL CERCLA site is closed out to ensure that the remedy provides adequate protection of human health and the environment. This review is required five years after finalizing the first ROD associated with the site. The ROD for OU-2 (NASA, 2002), which was signed in September 2002, was the first ROD completed for the JPL site (see 42 USC 9621(c)).

ROD Data Certification Checklist

The following information is included in Part II: Decision Summary of this Interim ROD. Additional information can be found on the Administrative Record Web site (available at http://jplwater.nasa.gov) or at the four Information Repositories (see Part III Responsiveness Summary for locations).

- Chemicals and their concentrations in off-facility groundwater, Section 5.0.
- Baseline risk represented by the chemicals in off-facility groundwater, Section 7.0
- Response action performance objectives for the chemicals in off-facility groundwater, Sections 8.0 and 11.0
- How chemicals in off-facility groundwater will be addressed, Section 11.0
- Current and reasonably anticipated future land use assumptions, Section 6.0
- Current and potential future beneficial uses of groundwater, Section 6.0
- Potential land and groundwater use that will be available as a result of the response action, Section 11.0
- Estimated capital, annual operation and maintenance (O&M) and total present worth costs, Section 11.0
- Number of years that response action is expected to operate, Sections 9.0 and 11.0
- Key factors that lead to selecting the response action, Sections 9.0, 10.0, 11.0, and 12.0.

FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY:

E. Trinh

Dr. Eugene Trinh, Director
NASA Management Office
Jet Propulsion Laboratory

5/7/07
Date

FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY:

Kathleen H. Johnson, Chief
Federal Facilities and Site Cleanup Branch
Superfund Division
U.S. Environmental Protection Agency, Region 9

6/28/07
Date

FOR THE STATE OF CALIFORNIA:

Sayareh Amir 4/17/07

Sayareh Amir, Chief
Southern California Cleanup Operations, Glendale Office
Department of Toxic Substances Control

Date

FOR THE STATE OF CALIFORNIA:

Deborah J. Smith, Interim Executive Officer
California Regional Water Quality Control Board
Los Angeles Region

8-1-07
Date

CONTENTS

Part I: DECLARATION ii

FIGURES xi
TABLES xii
ACRONYMS AND ABBREVIATIONS xiii

Part II: DECISION SUMMARY 1
1.0: SITE NAME, LOCATION, AND DESCRIPTION 1

2.0: SITE HISTORY 3

3.0: COMMUNITY PARTICIPATION 5

4.0: SCOPE AND ROLE OF OPERABLE UNIT 3 6

5.0: SITE CHARACTERISTICS (OPERABLE UNIT 3) 9
5.1 JPL and Operable Unit 3 Area Setting 9
5.2 Sources of Chemicals in Groundwater at JPL 9
5.3 Current Nature and Extent of Chemicals in Groundwater at JPL 9
5.3.1 Perchlorate 11
5.3.2 Carbon Tetrachloride 13
5.3.3 Trichloroethylene 16
5.3.4 Tetrachloroethene 18
5.4 Chemicals Identified Since Completion of the OU-1/OU-3 RI 19
5.5 Fate and Transport of Chemicals in Soil at JPL 21
5.6 Exposure Pathways 21

6.0: CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES 22
6.1 Land Uses 22
6.2 Surface Water and Groundwater Uses 22

7.0: SUMMARY OF SITE RISKS (OPERABLE UNIT 3) 23
7.1 Summary of Human Health Risk Assessment 23
7.2 Summary of Ecological Risk Assessment 25
7.3 Basis for Action 26

8.0: REMEDIAL ACTION OBJECTIVES 27

9.0: DESCRIPTION OF ALTERNATIVES 28
9.1 Alternative 1: No Further Action 30
9.1.1 Description of Remedy Components 30
9.1.2 Common Elements and Distinguishing Features 30
9.1.3 Expected Outcomes 30
9.2 Alternative 2: Centralized Treatment 30

9.2.1 Description of Remedy Components 30
9.2.2 Common Elements and Distinguishing Features 31
9.2.3 Expected Outcomes 32
9.3 City of Pasadena Treatment System Location 32

10.0: SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES 39
10.1 Comparison of Remedial Alternatives Using Evaluation Criteria 39
10.2 Protection of Human Health and the Envrironment 39
10.3 Compliance with Applicable or Relevant and Appropriate Requirements 41
10.4 Long-Term Effectiveness and Performance 41
10.5 Reduction of Toxicity, Mobility, or Volume Through Treatment 42
10.6 Short-Term Effectiveness 42
10.7 Implementability 43
10.8 Costs 44
10.9 State Acceptance 45
10.10 Community Acceptance 45

11.0: THE SELECTED REMEDY 47
11.1 Rationale for the Selected Remedy 47
11.2 Description of the Selected Remedy 47
11.3 Estimated Remedy Costs 48
11.4 Expected Outcomes of the Selected Remedy 51

12.0: STATUTORY DETERMINATIONS 53
12.1 Protection of Human Health and the Environment 53
12.2 Compliance with Applicable or Relevant and Appropriate Requirements 53
12.2.1 Chemical Specific ARARs 54
12.2.2 Action Specific ARARs 55
12.2.3 Location Specific ARARs 55
12.3 Cost-Effectiveness 57
12.4 Use of Permanent Solutions and Alternative Treatment Technologies 59
12.5 Preference for Treatment as a Principal Element 59
12.6 Five-Year Review Requirements 59

REFERENCES 60

Part III: THE RESPONSIVENESS SUMMARY 63

APPENDICES
Appendix A: Administrative Record File for OU-3
Appendix B: Collection of Public Letters, Emails and Comment Cards

FIGURES

Figure 1-1. Map of JPL and the Surrounding Area 2
Figure 4-1. Conceptual Representation of the Groundwater Cleanup Program at JPL 8
Figure 5-1. Potential Historical Chemical Waste Disposal Locations at the JPL Facility 10
Figure 5-2. Site Map Showing the Areal Extent of Perchlorate in Groundwater at Concentrations Greater than the California Public Health Goal 12
Figure 5-3. Cross-Section Showing the Vertical Extent of Perchlorate in Groundwater at Concentrations Greater than the California Public Health Goal 13
Figure 5-4. Site Map Showing the Areal Extent of CCl_4 in Groundwater at Concentrations Greater than the California MCL 15
Figure 5-5. Cross-Section Showing the Vertical Extent of CCl_4 in Groundwater at Concentrations Greater than the State of California MCL 16
Figure 5-6. Site Map Showing the Areal Extent of TCE in Groundwater at Concentrations Greater than the Federal and State of California MCL 17
Figure 5-7. Site Map Showing the Areal Extent of PCE in Groundwater at Concentrations Greater than the Federal and State of California MCL 19
Figure 9-1. Aerial Photograph Showing Six Areas Near Arroyo Seco Considered as Locations for the City of Pasadena Groundwater Treatment Facility 35
Figure 11-1. Map Depicting the Location of the Windsor Reservoir and the City of Pasadena Production Wells 49
Figure 11-2. Process Flow Diagram for the City of Pasadena Centralized Treatment System ... 49

TABLES

Table 5-1. Summary of Target Chemical Concentrations in Off-Facility Groundwater Monitoring Wells 11
Table 5-2 Summary of Maximum Concentrations (µg/L) of Perchlorate in OU-3 Wells During May/June 2006 11
Table 5-3 Summary of Maximum Concentrations (µg/L) of CCl_4 in OU-3 Wells During May/June 2006 14
Table 5-4 Summary of Maximum Concentrations (µg/L) of TCE in OU-3 Wells During May/June 2006 17
Table 5-5 Summary of Maximum Concentrations (µg/L) of PCE in OU-3 Wells During May/June 2006 18
Table 5-6. Summary of Maximum Concentrations of Chemicals in Detected in Off-Facility Groundwater During the Comprehenisve Monitoring Event (December 2002 to January 2003) 20
Table 7-1. Summary of Noncancer Hazard Index and Cancer Risk for OU-3 Monitoring Wells 24
Table 9-1. Evaluation Summary for the Location of the City of Pasadena System 36
Table 10-1. Comparison Summary of Remedial Alternatives for OU-3 40
Table 10-2. Comparison of Cost Estimates for Alternatives 1 and 2 45
Table 11-1. Estimate of Capital Costs for the Selected Remedy 50
Table 11-2. Estimate of Annual Operation and Maintenance Costs for the Selected Remedy ... 50
Table 11-3. Present Worth Estimate of Total Costs for Centralized Treatment, Continued Groundwater Monitoring, and Continued Funding of the LAWC Treatment System 51
Table 12-1. Summary of ARARs Relevant to the Selected Remedy for OU-3 56
Table 12-2. Comparison of Costs and Effectiveness of Alternatives for OU-1 58

ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement(s)
ATSDR	Agency for Toxic Substances and Disease Registry
Cal/EPA	State of California, Environmental Protection Agency
Caltech	California Institute of Technology
CCl_4	carbon tetrachloride
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COPC	chemical of potential concern
DHS	(California) Department of Health Services
DTSC	Department of Toxic Substances Control
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
FBR	fluidized bed reactor
FWEC	Foster Wheeler Environmental Corporation
gpm	gallons per minute
HCl	hydrochloric acid
HHRA	human health risk assessment
HI	hazard index
HMX	high-velocity military explosive
HQ	hazard quotient
HSC	(California) Health and Safety Code
JPL	Jet Propulsion Laboratory
LAWC	Lincoln Avenue Water Company
LGAC	liquid-phase granular activated carbon
MCL	maximum contaminant level
µg/L	microgram per liter
MW	monitoring well
NA	not applicable
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

ACRONYMS AND ABBREVIATIONS (Continued)

NDMA	nitroso-dimethylamine
NDPA	n-nitrosodi-n-propylamine
NDPHA	n-nitrosodiphenylamine
NEPA	National Environmental Policy Act of 1969
NFA	no further action
NPL	National Priorities List
O&M	operation and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OU	operable unit
PCE	tetrachloroethene
PHG	Public Health Goal
RCRA	Resource Conservation and Recovery Act
RDX	royal demolition explosive
RI	Remedial Investigation
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act of 1986
SCAQMD	South Coast Air Quality Management Board
SDWA	Safe Drinking Water Act
TBC	to be considered
TCE	trichloroethylene
1,2,3-TCP	1,2,3-trichloropropane
TNT	2,4,6-trinitrotoluene
UCL	upper confidence level
USC	United States Code
VOC	volatile organic compound

Part II: DECISION SUMMARY

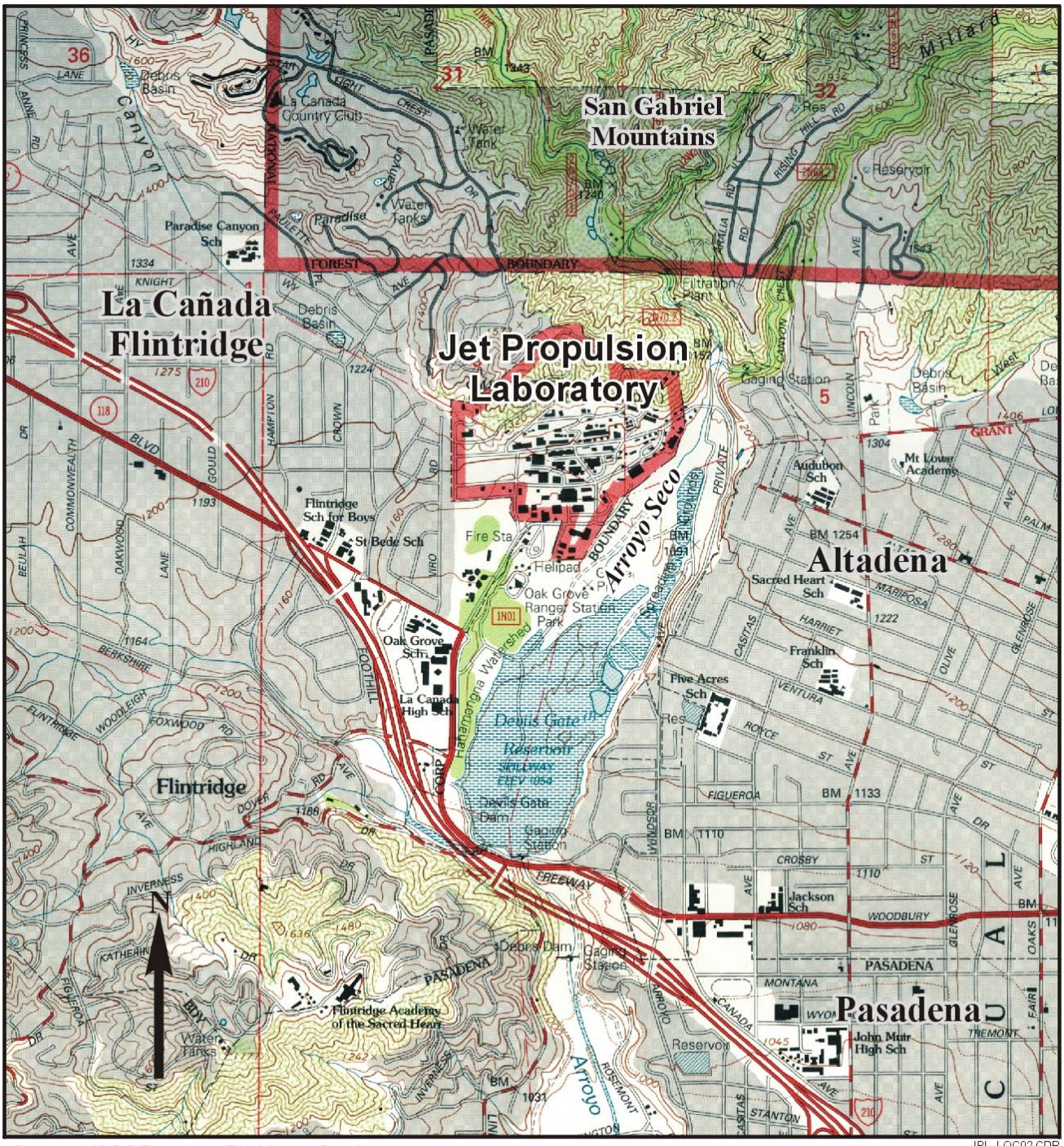
1.0: SITE NAME, LOCATION, AND DESCRIPTION

SITE NAME:	Jet Propulsion Laboratory (JPL)
EPA ID NUMBER:	CA9800013030; Federal Facility Agreement Docket Number 1998-27
LOCATION:	4800 Oak Grove, Pasadena, California
SITE TYPE:	Federal facility; Government-owned, contractor-operated
LEAD AGENCY:	National Aeronautics and Space Administration (NASA)
SUPPORTING AGENCIES:	U.S. Environmental Protection Agency (EPA), Region IX; State of California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC); and California Regional Water Quality Control Board (RWQCB), Los Angeles Region
OPERABLE UNIT:	Operable Unit 3 (OU-3), off-facility groundwater

NASA is the lead federal agency for selecting, implementing, and funding remedial activities at JPL. EPA, DTSC, and RWQCB provide independent oversight and technical assistance.

JPL is a federally-funded Research and Development Center in Pasadena, California, currently operated under contract by the California Institute of Technology (Caltech) for NASA. JPL's primary activities include the exploration of the earth and solar system by automated spacecraft and the design and operation of the Global Deep Space Tracking Network.

Located in Los Angeles County, JPL adjoins the incorporated cities of La Cañada-Flintridge and Pasadena, and is bordered on the east by the unincorporated community of Altadena. JPL encompasses approximately 176 acres of land and more than 150 buildings and other structures. Of the JPL facility's 176 acres, approximately 156 acres are federally-owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Development at JPL is primarily located on the southern half, in two regions − an early-developed northeastern area and a later-developed southwestern area. Figure 1-1 is a map showing the JPL facility and surrounding areas.



Source: USGS Pasadena 7½-Minute Quad, 1995.
Note: (1) Devil's Gate Reservoir is dry most of the year.

Figure 1-1. Map of JPL and the Surrounding Area

2.0: SITE HISTORY

During historic operations at JPL, various chemicals (including chlorinated solvents, solid rocket fuel propellants, cooling tower chemicals, sulfuric acid, Freon™, and mercury) and other materials were used at the site. During the 1940s and 1950s, many buildings at JPL maintained subsurface seepage pits for disposal of sanitary wastes and laboratory chemical wastes collected from drains and sinks within the buildings. A review of historical operations data indicated that 40 seepage pits, five waste pits, and four discharge points were used at the site (Foster Wheeler Environmental Corporation [FWEC], 1999). Some of the pits and discharge points received VOCs and other waste materials which are currently found in the soil and groundwater beneath JPL. In the late 1950s and early 1960s, a sanitary sewer system was installed at JPL to handle sewage and wastewater, and the use of seepage pits for sanitary and chemical waste disposal was discontinued. Today, laboratory chemical wastes are either recycled or sent off-site for treatment and disposal at regulated, Resource Conservation and Recovery Act (RCRA)-permitted hazardous waste facilities.

In 1980, the analyses of groundwater revealed the presence of VOCs in City of Pasadena water-supply wells located southeast of JPL in the Arroyo Seco. At about the same time, VOCs were detected in two water-supply wells used by the Lincoln Avenue Water Company (LAWC), located east of the Arroyo Seco (FWEC, 1999). In 1984, increasing concentrations required that these production wells be shut down.

In 1988, a Preliminary Assessment/Site Inspection was completed at JPL, which indicated that further site characterization was warranted (Ebasco, 1988). Subsequent site investigations were conducted at JPL (Ebasco, 1990a; Ebasco, 1990b) and VOCs were detected in on-facility groundwater at levels above drinking water standards. In 1992, JPL was placed on the National Priorities List (NPL) of sites subject to regulation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (47189-47187 *Federal Register*, 1992, Vol. 57, No. 199).

A Remedial Investigation (RI) for groundwater at the JPL site was conducted from 1994 to 1998. The OU-1/OU-3 RI Report (FWEC, 1999), which characterized the nature and extent of the chemicals in the groundwater, was completed in the fall of 1999. This report contained human health and ecological risk assessments looking at the possible effects to human health and the environment in the absence of any cleanup action (i.e., if no cleanup occurred). During the RI, a quarterly groundwater monitoring program was initiated in August 1996 to monitor VOCs and other chemicals, including perchlorate, metals, anions, cations, and other field parameters. Analytical results are summarized in quarterly reports and technical memoranda that are available in the Information Repositories and on the project Web site (http://jplwater.nasa.gov).

A draft Feasibility Study was completed in January 2000 (FWEC, 2000b) to evaluate potential response actions for groundwater at the JPL site. In addition, extensive groundwater modeling and aquifer testing (NASA, 2003b) at and adjacent to the JPL site has been conducted to characterize the complex groundwater conditions and groundwater flow.

In addition to these studies, NASA funded treatment facilities for LAWC in Altadena and for the City of Pasadena in the early 1990s to remove VOCs from drinking water wells that were affected by chemicals from JPL. In July 2004, NASA implemented a Removal Action directed at the off-facility groundwater to achieve quick, protective results by funding additional treatment facilities at LAWC to remove perchlorate in addition to VOCs. The perchlorate removal system uses an ion-exchange technology that has worked well, successfully treating over one billion gallons of water since initiating operation.

NASA has performed a number of studies to determine the best technologies for treating groundwater. In the late 1990s and early 2000s, NASA conducted pilot testing of several technologies to address dissolved perchlorate in source area groundwater, including a study that evaluated the effectiveness of a biological treatment technology called a fluidized bed reactor (FBR). Based on these studies, NASA installed a demonstration treatment plant in early 2005 located on the JPL property in the OU-1 source area. This system, which consists of liquid-phase granular activated carbon (LGAC) treatment to remove VOCs and an FBR to remove perchlorate, has been successful in the demonstration phase. A Proposed Plan to expand the demonstration system was issued in November 2005, which described NASA's preferred alternative for OU-1 source area groundwater. NASA and the regulators completed and signed the Interim Record of Decision (ROD) for OU-1 in February 2007. Source area treatment consists of pumping water out of the ground, treating it, and then reinjecting the water back into the ground. Water treated at the source area treatment plant is not used for drinking water purposes.

In April 2006, NASA issued the Proposed Plan for OU-3. Public comments were received from April to July 2006 and have been addressed in Part III of this Interim ROD for OU-3.

Appendix A is a listing of documents contained in the Administrative Record that are associated with this Interim ROD.

3.0: COMMUNITY PARTICIPATION

A complete summary of community involvement activities over the past five years is provided in the Community Involvement Plan (NASA, 2006a). This section summarizes the recent community involvement conducted in 2006 directly associated with the OU-3 response action.

On April 19, 2006, NASA issued the *Proposed Plan to Fund Construction and Operation of Treatment Systems for Groundwater from Drinking Water Wells,* which presented the Preferred Alternative for implementing a response action at OU-3 (NASA, 2006b). NASA mailed a newsletter describing the OU-3 Proposed Plan to over 17,000 area residents on April 14, 2006. A small meeting was held on April 21, 2006, at Five Acres School for residents within 500 feet of the proposed Windsor Avenue location. A formal Public Meeting was held on May 3, 2006, to address the Proposed Plan and to allow the public to comment or ask questions about the Proposed Plan and the Preferred Alternative identified in that Proposed Plan. Public notifications of the Proposed Plan and public meeting were mailed to the approximately 17,000 residents of the surrounding communities, and were e-mailed to approximately 5,000 JPL employees. Public notification of the meeting on May 3, 2006, was also provided in three local newspapers.

Based on requests from the public received during the May 3, 2006, Public Meeting, NASA extended the public comment period on the OU-3 Proposed Plan from May 19 to July 7, 2006, and also issued a Technical Memorandum that presented an *Alternatives Evaluation for the City of Pasadena Treatment Plant* (NASA, 2006c). This evaluation was intended to present the public with additional information relating to all of the locations considered for centralized treatment and the basis for the selection of the Windsor Reservoir. An opportunity to discuss the information presented in this Technical Memorandum was provided at an additional public meeting on June 21, 2006. Residents were informed of the June 21, 2006, meeting and the public comment period extension through newspaper advertisements in three local newspapers, community flyers distributed to local organizations, and a postcard mailing to over 17,000 local residents on NASA's mailing list. Residents within 500 feet of Windsor Reservoir also were made aware of the meeting via letters.

NASA continues to regularly update its Web site (http://jplwater.nasa.gov) with news and information about the cleanup project. Official documents related to the cleanup can also be found in the Administrative Record section of this Web site, or at the four Information Repositories.

4.0: SCOPE AND ROLE OF OPERABLE UNIT 3

CERCLA requires a thorough and often lengthy process to fully investigate and determine the best methods for cleanup. As the responsible agency, NASA has conducted a number of detailed investigations and studies on the site and adjacent areas since the early 1990s. These studies have helped NASA identify and understand the type and extent of chemicals in soil and groundwater. As part of this effort, NASA divided the site into three separate areas referred to as Operable Units (OUs). Designated by numbers, OU-1 consists of on-facility groundwater (the "source area"), OU-2 consists of on-facility soils, and OU-3 consists of off-facility groundwater adjacent to JPL. Ultimately, NASA will evaluate the entire site to ensure that the remedies, taken together, achieve cleanup requirements.

NASA has already implemented several cleanup initiatives to accelerate the remediation of groundwater and soil at JPL. A soil vapor extraction system (OU-2) has successfully treated concentrations of VOCs in soil, achieving the specified cleanup objectives. In addition, an on-facility extraction, treatment and reinjection system (OU-1) is currently operating within the JPL fence line to remediate water in the source area groundwater located underneath the JPL property.

In July 2004, as part of the cleanup effort to address chemicals in off-facility groundwater (i.e., OU-3), NASA conducted a Removal Action (NASA, 2004). This removal action consisted of funding the addition of an ion exchange treatment component at the LAWC treatment system to address perchlorate. NASA initially funded LAWC to construct a system in 1992 to address VOCs in groundwater. The perchlorate removal system uses ion-exchange technology and the VOC removal system uses LGAC. Both technologies have worked well, successfully treating over one billion gallons of water since initiating operation.

This Interim ROD addresses a response action for cleaning up the off-facility groundwater, which is the deep groundwater outside the JPL fence line. This Interim ROD documents two separate actions as part of OU-3:

1. Work closely with the City of Pasadena and fund the construction and operation of a treatment system for groundwater from the four City drinking water wells located just east of JPL near the Arroyo Seco. NASA will directly administer some of the work associated with siting the new City of Pasadena treatment system. NASA also will provide some technical support to the City for the permitting process. The City of Pasadena is required by its own ordinances to go through several permitting processes, some of which include public review.

2. Continue to fund treatment of groundwater from two LAWC drinking water wells at the existing treatment facility. The LAWC system is currently funded by NASA as a CERCLA removal action.

This response action is necessary to remove target chemicals from the aquifer being used by the local community (LAWC and the City of Pasadena) for drinking water. In addition, active treatment will provide an additional level of hydraulic control to prevent the migration of chemical mass in groundwater. This response action is being implemented as an interim action

in recognition that NASA intends to implement a final remedy for the entire groundwater chemical plume associated with the JPL site (i.e., both on-facility and off-facility groundwater). NASA will evaluate the results from both the on-facility source area reduction interim action (NASA, 2006f) and this interim action to aid the development of the final remedy for groundwater at JPL.

Figure 4-1 depicts a conceptual representation of the overall cleanup program that has been developed to achieve cleanup of the aquifer. The OU-3 response action described in this Interim ROD is part of a comprehensive approach to develop a final remedy that will successfully remediate target chemicals in groundwater. This approach includes soil (OU-2) and source area groundwater (OU-1) treatment within the JPL fence line, mid-plume treatment using the four City of Pasadena drinking water wells, and treatment of the leading edge of the plume using the two wells owned by LAWC.

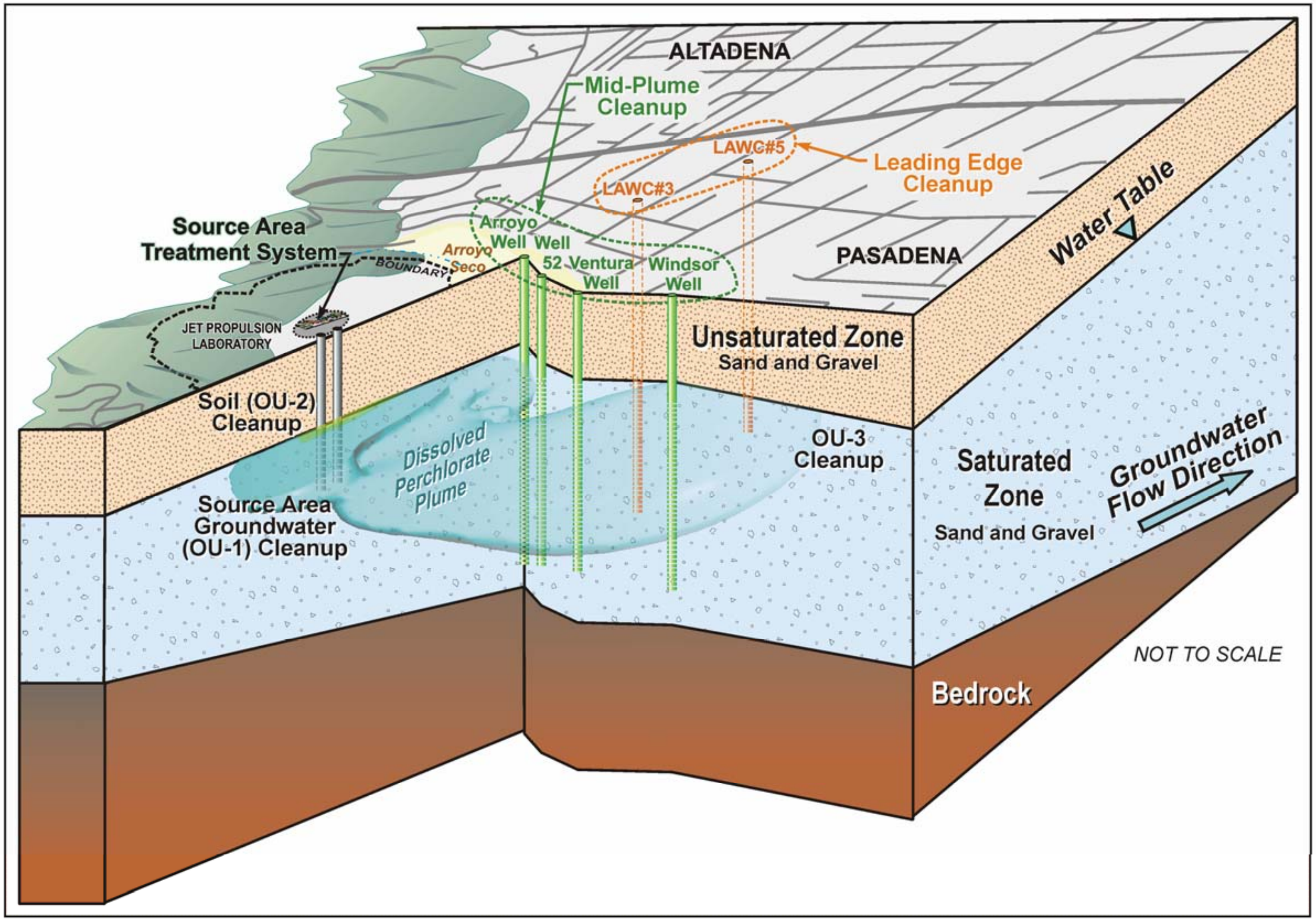


Figure 4-1. Conceptual Representation of the Comprehensive Groundwater Cleanup Program at JPL

5.0: SITE CHARACTERISTICS (OPERABLE UNIT 3)

5.1 JPL and OU-3 Area Setting

A description of the JPL facility and OU-3, including a discussion of the regional demographics, climate, physiography, geology, hydrology, hydrogeology, natural resources, and cultural resources, can be found in the *National Environmental Policy Act of 1969 (NEPA) Values Assessment* (NASA, 2006d).

5.2 Sources of Chemicals in Groundwater at JPL

The OU-1/OU-3 RI Report (FWEC, 1999) identified various chemicals and materials used during the operational history of the JPL facility. The general types of materials used and produced include a variety of solvents, solid and liquid rocket fuel propellants, cooling-tower chemicals, and analytical laboratory chemicals. Many buildings at JPL used seepage pits during the 1940s and 1950s to dispose of liquid and solid materials via infiltration into surrounding soil (see Figure 5-1). Some of these seepage pits may have received halogenated solvents, solid fuel residue containing perchlorate, and other chemicals currently found in the groundwater at the JPL facility and surrounding areas. In the late 1950s and early 1960s, a sewer system was installed at JPL, and the use of seepage pits for waste disposal was discontinued.

Of the 40 seepage pits identified at JPL, nine were identified as possible disposal locations for solid rocket propellant. Solid rocket propellant contains ammonium perchlorate, which is found in groundwater deep beneath the JPL facility and surrounding areas. The results of the OU-1/OU-3 RI and ongoing groundwater monitoring have indicated that concentrations of VOCs and perchlorate are present in groundwater within OU-3 (FWEC, 1999).

5.3 Current Nature and Extent of Chemicals in Groundwater at JPL

In support of the OU-1/OU-3 RI, groundwater samples were collected from June/July 1994 through January/February 1998. At the time of the OU-1/OU-3 RI sampling effort, five monitoring wells were located within OU-3, including MW-17, MW-18, MW-19, MW-20, and MW-21. During the OU-1/OU-3 RI, four chemicals (carbon tetrachloride [CCl_4], trichloroethylene [TCE], perchlorate, and chromium) were detected in OU-3 monitoring wells at concentrations above the drinking water standards for each chemical. Since that time, chromium has not been detected in any OU-3 monitoring wells at levels exceeding drinking water standards.

In 2004, two additional monitoring wells (MW-25 and MW-26) were installed further downgradient of the existing OU-3 monitoring network to evaluate perchlorate detections outside of the Monk Hill Subarea and determine the full extent of chemicals originating from JPL. These wells are currently sampled as part of the JPL monitoring network. A groundwater monitoring program has been in place at JPL since August 1996. JPL monitoring wells are sampled on a quarterly basis to maintain a comprehensive understanding of the subsurface conditions on and off the JPL property.

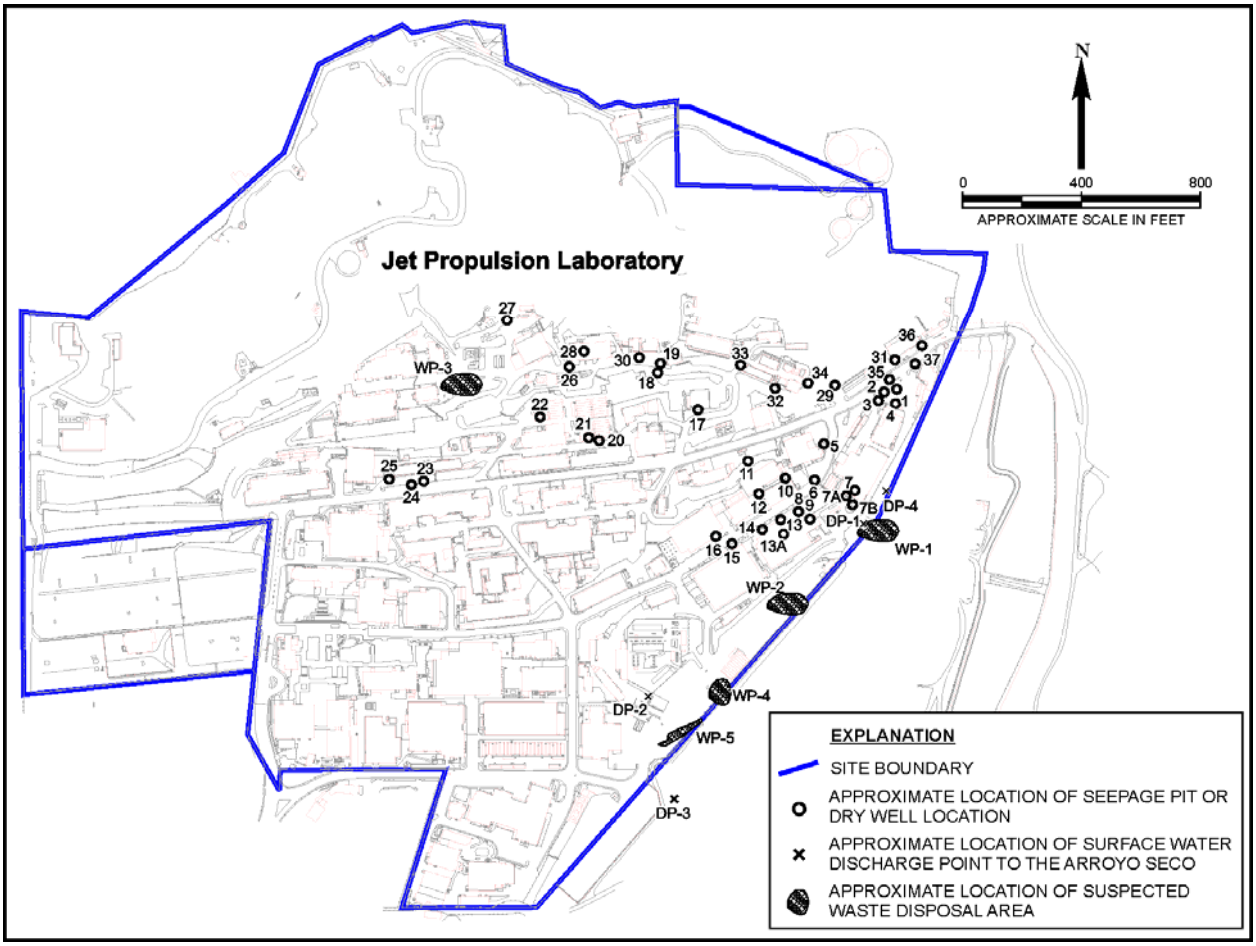


Figure 5-1. Potential Historical Chemical Waste Disposal Locations at the JPL Facility

The OU-3 monitoring wells (MW-17, MW-18, MW-19, MW-20, and MW-21) are sampled as part of the JPL groundwater monitoring program. Ongoing groundwater monitoring activities have indicated that four target chemicals (CCl_4, TCE, tetrachloroethene [PCE], and perchlorate) continue to be detected in JPL monitoring wells at concentrations above the state and federal drinking water standards for each chemical. Table 5-1 provides a summary of the maximum detected concentrations for each target chemical in OU-3 since groundwater monitoring was initiated at JPL. A detailed discussion of the nature and extent of these four target chemicals is presented in the following subsections.

Table 5-1. Summary of Target Chemical Concentrations in Off-Facility Groundwater Monitoring Wells

Target Chemical	Screening Criteria (µg/L)	Maximum Target Chemical Concentrations (1996 through June 2006)		
		Maximum (µg/L)	Date	Monitoring Well (Screen)
CCl_4	0.5(1)	14.9	Oct./Nov. 2004	17(3)
TCE	5(2)	35	Feb. 1996	21(1)
PCE	5(2)	28.6	Apr./May 2002	21(5)
Perchlorate	6(3)	209	July/Aug. 2003	17(3)

(1) California maximum contaminant level (MCL)
(2) Federal and California MCL
(3) California Public Health Goal (PHG)

5.3.1 Perchlorate

Historically, the highest levels of perchlorate have been reported in samples from on-facility (OU-1) wells, MW-7, MW-16, and MW-24. However, perchlorate has been detected in OU-3 monitoring wells at concentrations exceeding the California Public Health Goal (PHG) of 6 µg/L. During the May/June 2006 sampling event, perchlorate concentrations in excess of the PHG were reported in two (MW-17 and MW-18) of the five OU-3 monitoring wells located within the Monk Hill Subarea (see Table 5-2). Perchlorate concentrations in MW-17 [Screen 2] have consistently been detected within the range of 10 to 20 µg/L. Perchlorate concentrations in MW-17 [Screen 3] have been decreasing, with a detected concentration of 15 µg/L during the May/June 2006 sampling event. The highest concentration detected in MW-17 [Screen 3] was 209.0 µg/L in July/August 2003. Similarly, perchlorate concentrations in MW-18 [Screen 4] have decreased with a detected concentration of 11 µg/L during the May/June 2006 sampling event in May/June 2006. The highest concentration detected since 2003 at this location was 24.6 µg/L in January/February 2003. Conversely, perchlorate concentrations in Screen 3 of MW-18 have increased from approximately 1 µg/L in 2003 to 25 µg/L in the May/June 2006 sampling event.

Table 5-2. Summary of Maximum Concentrations (µg/L) of Perchlorate in OU-3 Wells During May/June 2006

Sampling Location	Maximum Detection (Screen)
MW-17	**15** (3)
MW-18	**25** (3)
MW-19	5.4 (2)
MW-20	< 4.0
MW-21	< 4.0

Bold indicates concentration greater than the PHG.

Perchlorate concentrations reported in groundwater collected from MW-19 have not been higher than the California PHG during the past three sampling events. Perchlorate concentrations in MW-19 [Screen 2] have been reported in the range of 4.0 to 8.0 µg/L during the 2004 sampling events and the first two quarters of 2005. During a sampling event in July/August 2004, perchlorate was detected at 9.7 µg/L in MW-19 [Screen 3], which is above the California PHG. Perchlorate concentrations in MW-20 and MW-21 have generally remained below the PHG for the past two years.

Figure 5-2 depicts the extent of perchlorate concentrations (from the May/June 2006 sampling event) in groundwater above the California PHG of 6 µg/L. Figure 5-3 presents a cross-sectional representation of the approximate centerline of the perchlorate plume.

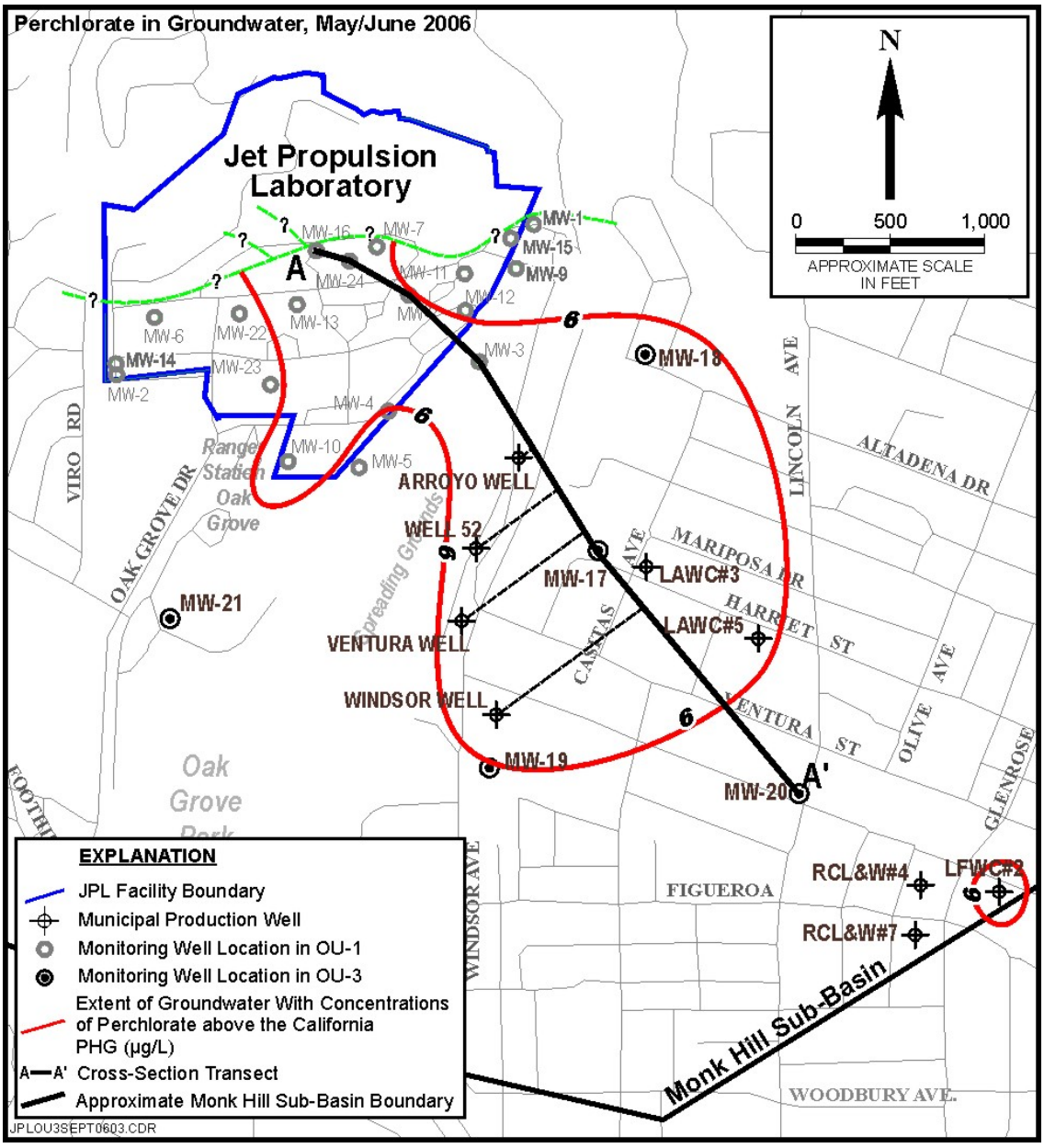


Figure 5-2. Site Map Showing the Extent of Perchlorate in Groundwater at Concentrations Greater than the California Public Health Goal

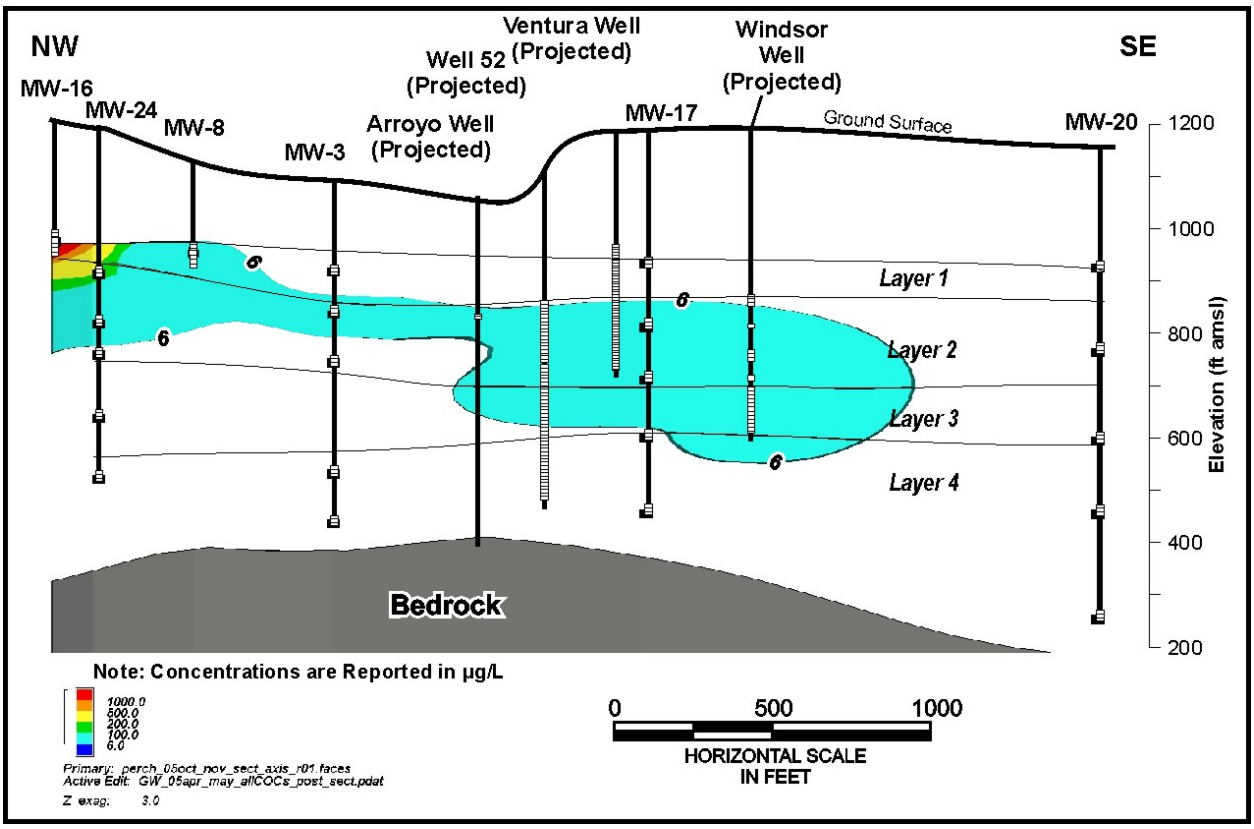


Figure 5-3. Cross-Section Showing the Vertical Extent of Perchlorate in Groundwater at Concentrations Greater than the California Public Health Goal

Since July 2004, perchlorate concentrations in LAWC Well No. 3 (LAWC#3) have ranged from 7.3 to 46 µg/L, with a concentration of 21 µg/L in July 2006; perchlorate concentrations in LAWC#5 have ranged from <4.0 to 9 µg/L, with a concentration of 7.3 µg/L in July 2006. Perchlorate concentrations in the four City of Pasadena production wells have been estimated to be below 45 µg/L (Pasadena, 2006a).

5.3.2 Carbon Tetrachloride

Concentrations of CCl_4 have been detected above the MCL (0.5 µg/L) in samples from all five OU-1 source area monitoring wells (MW-7, MW-8, MW-13, MW-16, and MW-24). The highest concentration of CCl_4 was reported in well MW-7 at 208 µg/L (April 2002). Concentrations in this well have since declined, reaching below the MCL in November 2005 as a result of the OU-1 source area treatment system. Similarly, CCl_4 concentrations in MW-24 reached the MCL for the first time in November 2005. CCl_4 concentrations in source area monitoring wells MW-13 and MW-16 (which will be addressed as part of the OU-1 treatment system expansion) remain above the MCL.

During the May/June 2006 sampling event, CCl_4 was detected in two of the five OU-3 monitoring wells (MW-17 and MW-18) at concentrations exceeding the California MCL of 0.5

µg/L. Table 5-3 summarizes CCl_4 concentrations for OU-3 monitoring wells during the May/June 2006 sampling event.

Historically, CCl_4 concentrations in MW-17 [Screen 3] have ranged from 0.5 µg/L to 14.9 µg/L. In MW-18, CCl_4 concentrations in Screen 4 ranged between 0.5 µg/L to 11.7 µg/L and concentrations in Screen 3 ranged between 0.5 µg/L to 4.8 µg/L.

Figure 5-4 depicts the extent of CCl_4 concentrations (from the May/June 2006 sampling event) in groundwater above the California MCL of 0.5 µg/L. Figure 5-5 presents a cross-sectional representation of the approximate centerline of the CCl_4 plume. The City of Pasadena production wells have been projected to show the spatial relationship between these production wells and the CCl_4 concentrations in groundwater.

Table 5-3. Summary of Maximum Concentrations (µg/L) of CCl_4 in OU-3 Wells During May/June 2006

Sampling Location	Maximum Detection (Screen)
MW-17	**2.16** (3)
MW-18	**4.76** (3)
MW-19	< 0.5
MW-20	< 0.5
MW-21	< 0.5

Bold indicates concentration greater than the state MCL.

Since 2004, CCl_4 concentrations in LAWC#3 have ranged from 0.8 to 4 µg/L, with a concentration of 2.7 µg/L in July 2006; CCl_4 concentrations in LAWC#5 have ranged from <0.5 to 0.8 µg/L, with a concentration of 0.8 µg/L in July 2006. CCl_4 concentrations in the four City of Pasadena production wells have been estimated to be below 2.7 µg/L (Pasadena, 2006a).

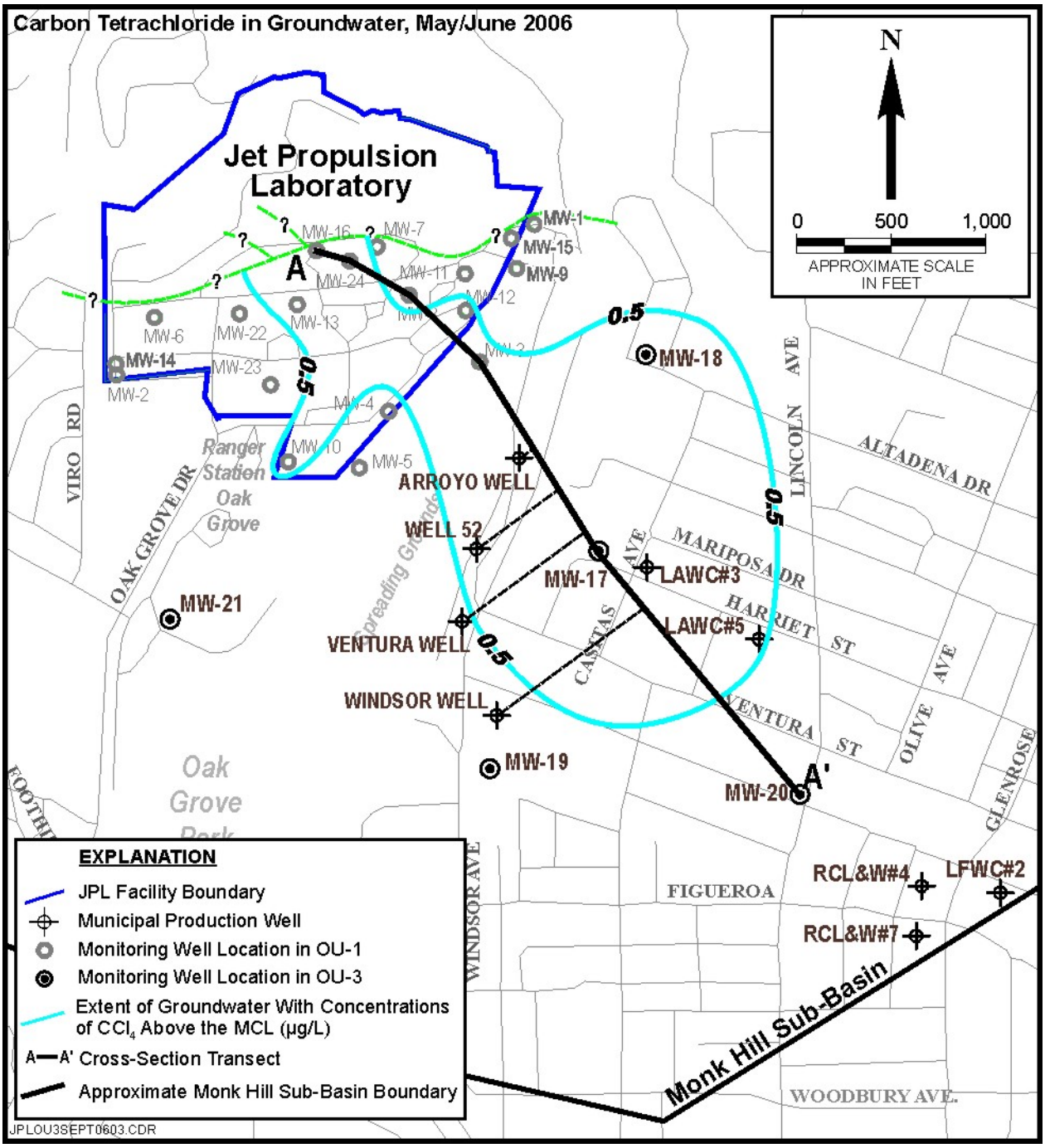


Figure 5-4. Site Map Showing the Extent of CCl_4 in Groundwater at Concentrations Greater than the California MCL

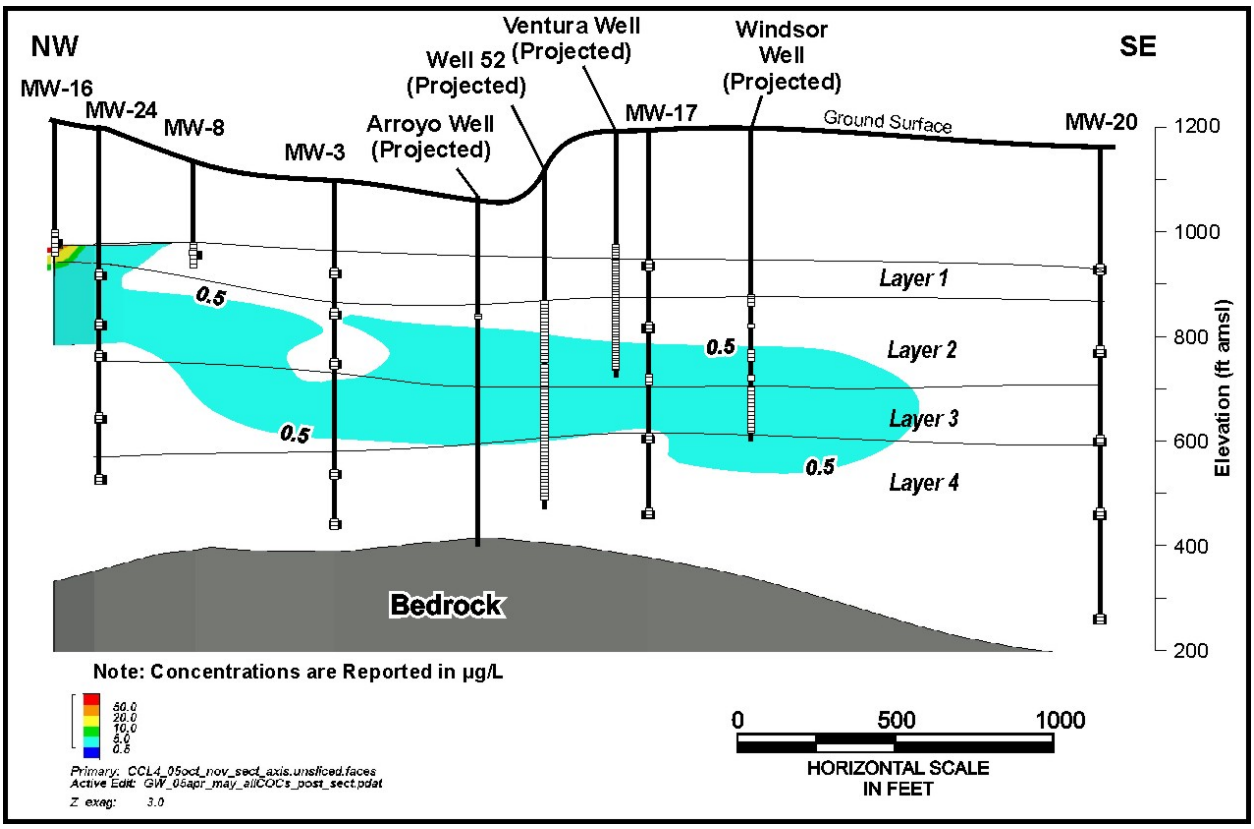


Figure 5-5. Cross-Section Showing the Vertical Extent of CCl_4 in Groundwater at Concentrations Greater than the State of California MCL

5.3.3 Trichloroethylene

Historically, TCE concentrations have exceeded the state and federal MCL (5.0 µg/L) in all five source area monitoring wells (MW-7, MW-8, MW-13, MW-16, and MW-24). The highest concentrations of TCE reported during the past decade occurred in September 1996 in wells MW-13 (47 µg/L), MW-7 (39 µg/L), and MW-16 (33 µg/L). Concentrations in these wells have since declined, and have remained below the MCL in MW-16 since 2001 and in MW-7 and MW-24 (as a result of the OU-1 source area treatment system). TCE concentrations MW-13 remain above the MCL.

During the May/June 2006 sampling event, TCE concentrations did not exceed the MCL in any of the OU-3 monitoring wells (see Table 5-4). Since 2003, TCE concentrations in MW-21 have exceeded the MCL in July/August 2003, at a concentration of 11 µg/L, and in October/ November 2003 at a concentration of 5.5 µg/L. In MW-17 [Screen 2], TCE concentrations exceeded the MCL in October/November 2003 and January/February 2005 with concentrations of 6.2 µg/L and 5.1 µg/L, respectively. A TCE concentration in Screen 4 of MW-17 was reported at 6.2 µg/L in April/May 2003 and has not exceeded the MCL since that time. TCE concentrations in MW-17 [Screen 5] have been reported below the MCL level since July/August 2002. Figure 5-6 depicts the extent of TCE concentrations (from the

May/June 2006 sampling event) in groundwater above the California and federal MCL of 5 µg/L. A cross-sectional representation has not been shown because the TCE contour map indicates that TCE concentrations above the MCL are primarily located within the JPL fence line and at LAWC#5.

Since July 2004, TCE concentrations in LAWC#3 have ranged from 1 to 4 µg/L, with a concentration of 2.6 µg/L in July 2006; TCE concentrations in LAWC#5 have ranged from 3.9 to 6.5 µg/L, with a concentration of 4 µg/L in July 2006. TCE concentrations in the City of Pasadena production wells have been estimated to be below 3.2 µg/L (Pasadena, 2006a).

Table 5-4. Summary of Maximum Concentrations (µg/L) of TCE in OU-3 Wells During May/June 2006

Sampling Location	Maximum Detection (Screen)
MW-17	1.21 (3)
MW-18	0.86 (4)
MW-19	0.65 (2)
MW-20	< 0.5
MW-21	0.64 (3)

Bold indicates concentration greater than the state and federal MCL.

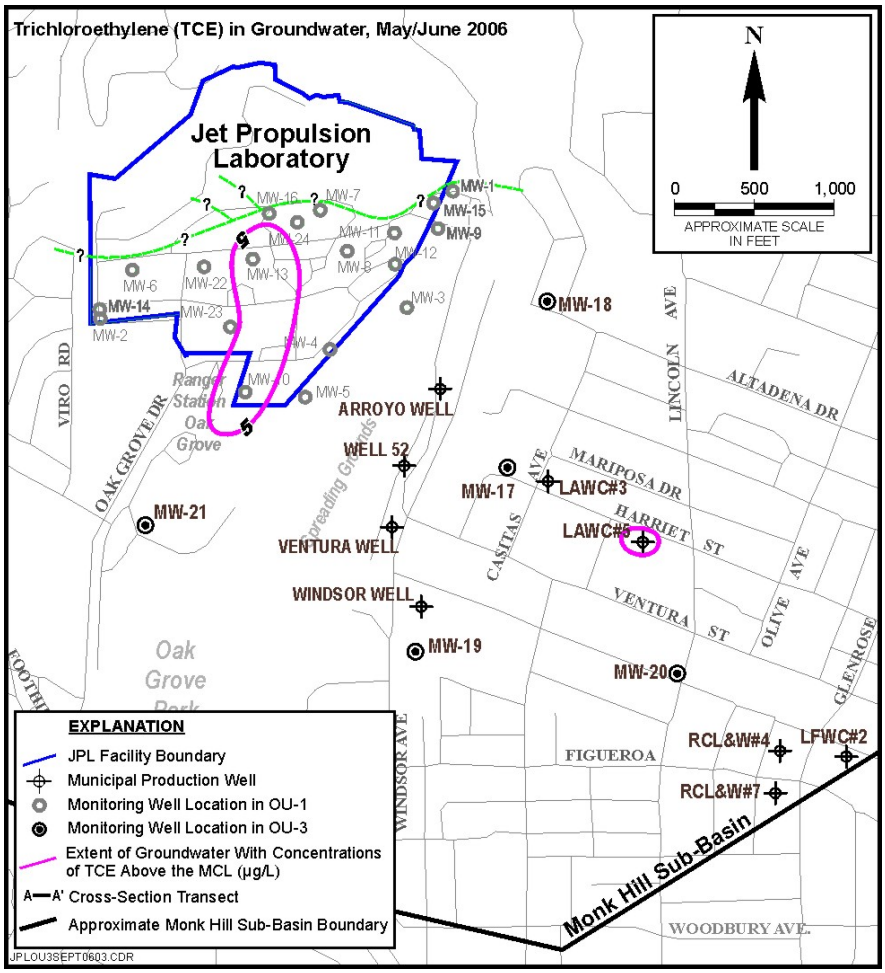


Figure 5-6. Site Map Showing the Extent of TCE in Groundwater at Concentrations Greater than the Federal and State of California MCL

5.3.4 Tetrachloroethene (PCE)

The highest historical concentration of PCE was detected in source area well MW-7 (34.7 µg/L) in November 2004. However, since the initiation of the OU-1 treatment system, concentrations in this well have been reduced to below the state and federal MCL (5.0 µg/L). Based on the current extent of PCE in groundwater (see Figure 5-7), PCE levels above the MCL are primarily in MW-16.

During the May/June 2006 sampling event, PCE was detected above the MCL in one out of the five (MW-21) OU-3 monitoring wells (see Table 5-5). Historically, PCE has exceeded the MCL of 5 µg/L in MW-19 [Screen 5] and MW-21 [Screens 2, 4, and 5]. During the April/May 2002 sampling event, PCE was detected at a concentration of 28.6 µg/L in MW-21 [Screen 5]. Figure 5-7 depicts the extent of PCE concentrations (from the May/June 2006 sampling event) in groundwater above the California and federal MCL of 5 µg/L. A cross-sectional representation has not been shown because the PCE contour map clearly shows that TCE concentrations above the MCL are primarily located within the JPL fence line and around MW-21.

Table 5-5. Summary of Maximum Concentrations (µg/L) of PCE in OU-3 Wells During May/June 2006

Sampling Location	Maximum Detection (Screen)
MW-17	< 0.5
MW-18	< 0.5
MW-19	3.05 (5)
MW-20	< 0.5
MW-21	**5.18** (2)

Bold indicates concentration greater than the state and federal MCL.

Since July 2004, PCE concentrations in LAWC#3 have ranged from non-detect to 0.67 µg/L, with a concentration of 0.6 µg/L in July 2006; PCE concentrations in LAWC#5 have ranged from non-detect to 0.7 µg/L, with a concentration of 0.6 µg/L in July 2006. PCE concentrations in the four City of Pasadena production wells have been estimated to be below 0.6 µg/L (Pasadena, 2006a).

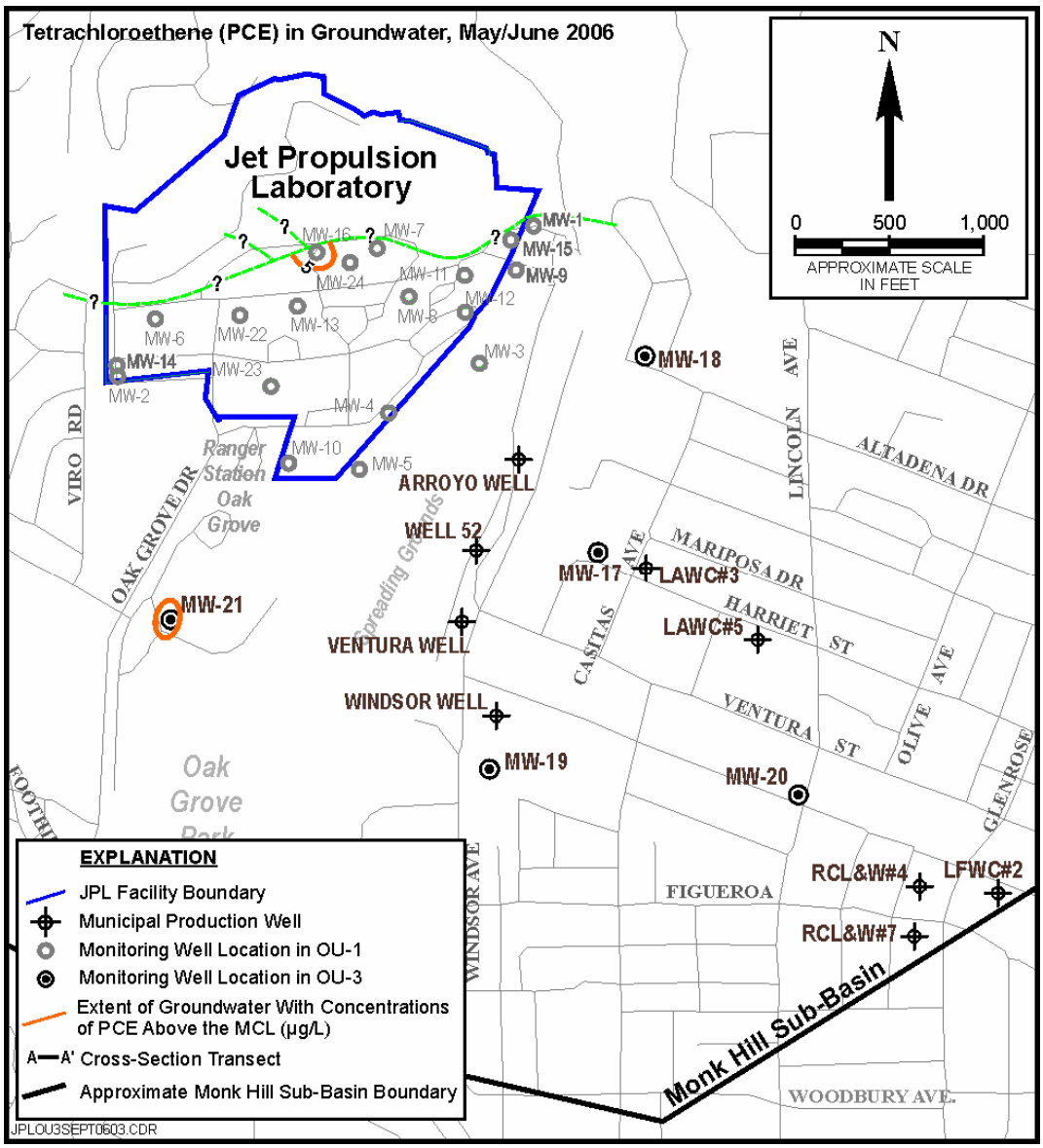


Figure 5-7. Site Map Showing the Extent of PCE in Groundwater at Concentrations Greater than the Federal and State of California MCL

5.4 Chemicals Identified Since Completion of the OU-1/OU-3 RI

Since completion of the OU-1/OU-3 RI, sampling of JPL monitoring wells has included additional analytes (e.g., 1,2,3-trichloropropane [1,2,3-TCP]; 1,4-dioxane; nitroso-dimethylamine [NDMA]) to evaluate drinking water permit considerations at the request of the California Department of Health Services (DHS). Since 2002, NASA has been working closely with DHS to support compliance with DHS Policy Memorandum 97-005 (see Section 12.2.2), which requires a thorough evaluation of an aquifer prior to the issuance of a drinking water permit.

A comprehensive monitoring event was conducted by NASA in December 2002 and January 2003 for select JPL monitoring wells to provide supplemental water quality data based on the analyses requested by DHS. Chemical constituents that were not routinely analyzed during the long-term quarterly groundwater monitoring events were included in this comprehensive sampling event. The JPL monitoring wells selected for the comprehensive groundwater monitoring event located in OU-3 included: MW-17 (Screens 3 and 4), MW-18 (Screens 3 and 4), MW-19 (Screens 3 and 5), MW-21 (Screens 3 and 5), and MW-24 (Screen 2). California DHS participated in the selection of the wells and analytical methods.

Chemicals selected during the comprehensive monitoring event that were not detected (or not analyzed for) in the historical JPL monitoring data obtained during the RI and long-term monitoring program included 2,4,6-trinitrotoluene (TNT), high-velocity military explosive (HMX); royal demolition explosive (RDX); n-nitrosodiphenylamine (NDPHA); n-nitrosodi-n-propylamine (NDPA), and NDMA. In addition, 1,2,3-TCP and 1,4-dioxane also were detected during the comprehensive event as well as in previous monitoring events. Table 5-6 summarizes the maximum concentrations of these chemicals detected in samples collected from the OU-3 groundwater monitoring wells.

In 2004, these chemicals were analyzed for in LAWC production wells (LAWC#3 and LAWC#5) and none were detected. Based on current estimates, 1,2,3-TCP may be present in one or more of the City of Pasadena production wells at concentrations greater than applicable drinking water notification level (Pasadena, 2006a). Any 1,2,3-TCP would be removed from groundwater using the LGAC treatment system. NASA and the City of Pasadena are currently working with DHS to ensure that these chemicals are considered in the design of a centralized treatment plant.

Table 5-6. Summary of Maximum Concentrations of Chemicals Detected in Off-Facility Groundwater during the Comprehensive Monitoring Event (December 2002 to January 2003)

Chemical	Notification Level[(a)] (µg/L)	Maximum Detected Concentration (µg/L)	Date of Maximum	Monitoring Well (Screen)
1,2,3-TCP	0.005	0.071	Jan. 2003	MW-18(4)
TNT	1	<0.11	NA	NA
HMX	350	<0.19	NA	NA
RDX	0.3	<0.19	NA	NA
NDMA	0.01	0.0016	Dec. 2002	MW-21(5)
NDPHA	0.01	0.00617	Dec. 2002	MW-19(5)
NDPA	0.01	<0.005	NA	NA
2,4-Dinitrotoluene	NA	<0.14	NA	NA
1,4-Dioxane	3	1.9	Dec. 2002	MW-18(4)

(a) Notification Levels have been referenced because neither federal nor state MCLs exist for any of the emerging constituents.

NA – not applicable

5.5 Fate and Transport of Chemicals in Groundwater

Figure 4-1 is a conceptual model for the transport of VOCs and perchlorate from the JPL seepage pits to groundwater at OU-3. The fate and transport characteristics and the potential for downgradient migration of chemicals were described in detail in the JPL OU-1/OU-3 RI (FWEC, 1999). Infiltration and percolation of rainfall, which causes vertical downward flow of VOCs and perchlorate from the vadose zone to groundwater, appears to be the principal transport mechanism at JPL. In the OU-1/OU-3 RI, the evaluation of chemical fate and transport focused on three VOCs (CCl_4, TCE, 1,2-dichloroethane), perchlorate, and Cr [both total Cr and Cr(VI)]. An additional VOC, PCE, which had been detected in groundwater samples from JPL monitoring wells at levels below state and federal MCLs at the time of the RI, was included in the fate and transport assessment at the request of the regulatory agencies.

5.6 Exposure Pathways

There is no way for residents who live in the areas overlying OU-3 to come in contact with untreated groundwater because the chemicals are located in groundwater which is over two hundred feet below the ground surface and does not recharge surface water bodies. Groundwater pumped from nearby water production wells must meet strict state and federal water quality standards prior to distribution to consumers. Production wells that have shown perchlorate and VOCs in the pumped groundwater have treatment in place (i.e., LAWC) or have been shut down pending construction of a treatment system (i.e., the City of Pasadena Monk Hill Subarea wells). No direct exposure pathways to OU-3 groundwater were identified in the OU-1/OU-3 RI report for the human or ecological receptors (FWEC, 1999). The only possible exposure pathway would be if a water treatment system malfunctioned. However, redundancies that are built into the treatment systems and continuous monitoring make this exposure pathway highly unlikely.

The ecological scoping assessment conducted as part of the OU-1/OU-3 RI concluded that no groundwater exposure pathways to plants and animals are possible at OU-3. Therefore, no further characterization of ecological risks to plants and animals due to groundwater impact was warranted.

More information on the results of the human health and ecological risk assessments is included in Section 7.0 of this document and in the OU-1/OU-3 RI report (FWEC, 1999).

6.0: CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

JPL is a NASA-owned, federally-funded research and development center operated by Caltech. It is the federal government's lead center for research and development related to robotic exploration of the solar system. In addition to NASA work, tasks for other federal agencies are conducted at JPL in areas such as remote sensing, astrophysics, and planetary science. The land use of areas surrounding JPL is primarily residential and light commercial.

6.1 Land Uses

JPL comprises about 176 acres of land. Of these 176 acres, about 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Presently, more than 150 structures and buildings occupy JPL. Total usable building space is approximately 1,330,000 ft^2. The main developed area of JPL is the southern half, which can be divided into two general areas − the northeastern early-developed area and the southwestern later-developed area. Most of the northern half of JPL is not developed because of steeply sloping terrain.

Currently, the northeastern, early-developed part of JPL is used for project support, testing, and storage. The southwestern, later-developed part is used mostly for administrative, management, laboratory, and project functions. Further development of JPL is constrained because of steeply sloping terrain to the north, the Arroyo Seco to the south and east, and residential development to the west.

Located at the northern boundary of JPL is the Gould Mesa area. This area has widely separated small buildings and is used primarily for antenna testing. The distance between buildings is a result of the terrain and the need to isolate transmitting and receiving equipment. The relatively steep mountainside between Gould Mesa and the developed area at JPL is unpopulated.

The primary land use in the areas surrounding JPL is residential and light commercial. Industrial areas, such as manufacturing, processing, and packaging, are limited. The closest residential properties are those located along the western fence line of JPL. The nearest off-facility buildings are the Flintridge Riding Club and Fire Camp #2, both located approximately 100 yards from the southern border of JPL. The total number of buildings within 2 miles of JPL is about 2,500, primarily residential and community (e.g., schools, day-care centers, churches). Land use at JPL and the areas surrounding JPL is not expected to change significantly in the foreseeable future.

6.2 Surface Water and Groundwater Uses

Seasonal rains may result in intermittent flows through the Arroyo Seco wash, which is located to the east of JPL. The entire JPL site drains, via storm drains and surface runoff, into the Arroyo Seco. In addition, stormwater runoff from parts of La Cañada-Flintridge combines with that of JPL prior to discharge to the Arroyo. Within the Arroyo Seco, a series of surface

impoundments are used as surface water collection and spreading basins for groundwater recharge.

The groundwater beneath the Arroyo Seco and within the capture zones of the production wells is a current source of drinking water. The Monk Hill Subarea is located within the Raymond Basin and is a source of potable groundwater for several communities in the area (Pasadena, La Cañada-Flintridge, and Altadena) (FWEC, 2000a). These communities are expected to grow at a modest rate for the foreseeable future and the demand for groundwater as drinking water is expected to continue.

7.0: SUMMARY OF SITE RISKS (OPERABLE UNIT 3)

This section of the Interim ROD summarizes the results of the baseline human health risk assessment (HHRA) and the ecological risk assessment (ERA) for OU-3. The risk assessment process identifies potential exposure pathways and allows evaluation of the risks to humans and the ecosystem if no further action was taken at the site.

7.1 Summary of Human Health Risk Assessment

The HHRA evaluated the potential risks to human health associated with hypothetical exposure to chemicals in untreated groundwater beneath the JPL facility. It is important to note that because groundwater is in a deep aquifer and does not recharge surface water bodies within the area of concern, and because water purveyors treat impacted groundwater before use, there is no direct pathway for exposure to groundwater. Nevertheless, a hypothetical residential use scenario was evaluated during the OU-1/OU-3 RI (FWEC, 1999) using EPA risk assessment guidance. It was assumed in the risk assessment that humans use untreated groundwater beneath JPL for potable purposes. Detailed results and methodologies used are presented in the OU-1/OU-3 RI (FWEC, 1999). To ensure that human health is adequately protected, upper bound exposure point concentrations and toxicity assumptions were used in estimating potential cancer risks and noncancer health hazards.

Twelve chemicals were identified as chemicals of potential concern (COPCs) and evaluated in the risk assessment. The COPCs included: arsenic, hexavalent chromium (Cr^{6+}), lead, nitrate, perchlorate, 1,1-dichloroethene, 1,2-dichloroethane, bromodichloromethane, CCl_4, chloroform, PCE, and TCE.

Risks are estimated as probabilities for COPCs that are considered carcinogens. The excess lifetime cancer risk is the incremental increase in the probability of developing cancer associated with exposures to contaminated media at the site over a lifetime. For example, a risk of 1×10^{-6} represents that there is one additional person in a million that will develop cancer as a result of exposure to the carcinogen over and above the background rate of developing cancer. The upper bound excess lifetime cancer risks derived in the risk assessment are compared to the risk range of 10^{-4} (one in ten thousand) to 10^{-6} (one in a million) (EPA, 1990).

For noncarcinogenic compounds, health hazards are estimated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose or level derived for a similar

exposure period that is not expected to cause any harmful effects. The ratio of the chronic daily dose to the reference dose is called a hazard quotient (HQ). The sum of the hazard quotients for all the chemicals at the site is referred to as the hazard index (HI). An HI less than 1.0 indicates that toxic, noncarcinogenic effects from all chemicals are unlikely (EPA, 1989).

Residential receptors were chosen to model exposure from hypothetical contact with chemicals in untreated groundwater at the JPL site. The residential receptors evaluated in the risk assessment included a default residential scenario for an adult and a child. This conservative exposure scenario evaluated an age-adjusted adult receptor (24 years as an adult and 6 years as a child, for a total of 30 years) for exposure to carcinogens and a child receptor (age 0-6 years) for noncarcinogens. Exposure to untreated chemicals of concern in groundwater was evaluated for ingestion, inhalation, and dermal contact at each JPL monitoring well. It was assumed that the receptors were exposed to the maximum detected or 95 percent upper confidence level (UCL) concentration of chemicals of concern (whichever was higher) in each well for 350 days per year. The exposure scenario is a hypothetical situation that does not reflect realistic current or future land-use scenarios because there are no direct exposure pathways for humans to interact with untreated groundwater in the study area.

The only way for the public to come in contact with the groundwater located several hundred feet below the ground surface is through pumping from drinking water production wells located off-facility. These production wells are either shut down or treated prior to water distribution to customers, thus preventing a direct exposure pathway.

Results for the hypothetical child receptor indicated that in the absence of cleanup, noncancer hazards were above 1 in four of the five OU-3 monitoring wells (see Table 7-1). However, in two of the wells with HIs above 1 (i.e., MW-18 and MW-20), chemical-specific HQs were all less than 1. Major chemical contributors in MW-17 and MW-21 were identified as perchlorate and TCE.

Table 7-1. Summary of Noncancer Hazard Index and Cancer Risk for OU-3 Monitoring Wells

Monitoring Well	Hazard Index	Major(1) Chemical Contributor	Risk	Major(2) Chemical Contributor
MW-17	8	perchlorate, TCE	8×10^{-5}	bromodichloromethane, CCl_4, chloroform, Cr^{6+}, TCE
MW-18	3	none	1×10^{-4}	arsenic, CCL_4, chloroform, Cr^{6+}, PCE, TCE
MW-19	<1	none	1×10^{-5}	bromodichloromethane, CCl_4, chloroform, Cr^{6+}, PCE
MW-20	2	none	7×10^{-5}	arsenic, bromodichloromethane, chloroform
MW-21	2	perchlorate	2×10^{-5}	PCE, TCE

(1) Defined as those chemicals having a HQ > 1.
(2) Defined as those chemicals having an individual total risk level greater than 1×10^{-6}.

Results of the cancer risk evaluation for OU-3 monitoring wells show that total estimated cancer risks (see Table 7-1) fall within EPA's range for acceptable levels of risk – 1×10^{-6} to 1×10^{-4}. Of the seven COPCs identified as major contributors to cancer risk (Table 7-1), the percent contribution to total risk was highest for arsenic, TCE, and PCE in wells where these COPCs were detected. Where arsenic was detected (MW-18 and MW-20), the total risk contribution ranged from 50% to 90% even though the arsenic exposure concentrations were less than the federal drinking water standard of 10 µg/L. Arsenic occurs naturally in groundwater and the detections reflect natural concentrations. As noted in the OU-1/OU-3 RI (FWEC, 1999), for both noncancer hazard and cancer risk estimates, only CCl_4, perchlorate, and TCE were present in OU-3 wells at levels exceeding state and federal drinking water standards. Bromodichloro-methane, chloroform, and PCE concentrations were below drinking water standards in OU-3 monitoring wells.

Lead exposure in groundwater was evaluated separately using DTSC models to estimate blood lead levels in adults and children. All estimated blood-lead levels were below the DTSC benchmark level of 10 µg/L.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted site visits in 1997 to assess the potential for public health hazards associated with the groundwater adjacent to the JPL facility. ATSDR identified the following primary community concerns: 1) future groundwater and drinking water quality and 2) increased incidence of Hodgkin's disease. Following a careful evaluation of available data, ATSDR determined that the VOCs in groundwater do not present a past, present, or future public health concern to JPL employees or nearby residents. On-facility groundwater has never been used as a source of drinking water and area water purveyors regularly monitor to ensure that water meets the federal and state water quality goals. Based on an analysis performed by the ATSDR, it was determined unlikely that perchlorate in groundwater posed a past public health hazard (ATSDR, 1998). Unlike state and federal guidance that requires the evaluation in HHRA of exposures to untreated groundwater, the ATSDR evaluated whether residents are actually being exposed currently, or may possibly be exposed in the future, to chemicals present in groundwater at JPL.

7.2 Summary of Ecological Risk Assessment

An assessment of ecological risks that qualitatively evaluated potential ecological receptors, COPCs, and potentially completed exposure pathways for soil, soil vapor, and groundwater was completed at JPL. A scoping assessment of ecological risks also was completed to qualitatively evaluate potential ecological receptors, COPCs, and potentially complete exposure pathways for groundwater. Groundwater typically underlies the ecological receptors at depths of approximately 200 ft or more, and for this reason, there are no plausible groundwater exposure pathways to plants and animals. It was concluded that no further characterization of ecological risks to plants and animals due to groundwater exposure was warranted as there were no complete exposure pathways (FWEC, 1999).

The assessment used a habitat approach as the basis for identifying potentially complete pathways between areas of impact and specific plant and animal species that may occupy the

facility. Potentially affected habitats within or adjacent to the JPL facility include: urban landscape, chaparral, riparian, wetlands, southern oak woodland, and desert wash. A wide variety of plant and animal species were catalogued during field surveys. The COPCs evaluated for groundwater were the metals and VOCs that were detected in the groundwater during the OU-1/OU-3 RI.

The chaparral and southern oak woodland habitats are found only in the San Gabriel Mountains to the north of the JPL facility. Because no impact was known or suspected within the chaparral and southern oak woodland habitats, no potential exposure pathways were identified for these habitats. The riparian, desert wash, and wetland habitats occur off-facility (OU-3) only, and groundwater typically underlies these habitats at depths of approximately 100 ft or more. For this reason, there were no plausible groundwater exposure pathways to plants and animals within riparian, desert wash, or wetland habitats identified during the ERA. The urban landscape habitat is the predominant on-facility JPL habitat. Constituents in groundwater are found at depths between approximately 100 ft to 250 ft and groundwater does not recharge on-facility surface water bodies. Therefore, no groundwater exposure pathways to plants and animals were identified.

Therefore, it was concluded that no further characterization of ecological risks to plants and animals due to groundwater impact was warranted because there were no complete exposure pathways from groundwater to on-facility biota.

7.3 Basis for Action

The groundwater outside the JPL fence line contains elevated levels of VOCs and perchlorate, which requires treatment prior to drinking water use by the local community. The basis for this response action is to remove target chemicals from the aquifer being used by the local community (LAWC and the City of Pasadena) for drinking water, as well as to prevent additional migration of chemicals in groundwater outside the JPL fence line.

This response action is part of a comprehensive approach to characterization and cleanup of groundwater affected by chemicals originating from the JPL facility.

8.0: REMEDIAL ACTION OBJECTIVES

This response action is intended to remove target chemicals from the aquifer being used by the local community (LAWC and the City of Pasadena) for drinking water, to protect the environment from the additional migration of chemicals in groundwater outside the JPL fence line, and to provide additional data to assess the likelihood of restoring groundwater to meet applicable or relevant and appropriate requirements (ARARs) (i.e., restoration potential). The remedial action objectives for this response action are as follows:

- Remove target chemicals from the aquifer by treating water pumped from specified drinking water wells in the Monk Hill Subarea of the Raymond Basin (referred to as centralized treatment)

- Prevent further migration of the chemicals in groundwater

- Provide additional data to assess possible long-term cleanup remedies for groundwater both on and off the JPL facility.

9.0: DESCRIPTION OF ALTERNATIVES

NASA identified and evaluated alternatives to achieve the remedial action objectives. The selected remedy for OU-3 is the centralized treatment alternative, as it provides the best approach to meet the remedial action objectives. This alternative includes the design, installation and operation of treatment systems to remove perchlorate and VOCs in groundwater extracted from the LAWC and City of Pasadena production wells located within the Monk Hill Subarea. The LAWC centralized treatment system has been operational since the summer of 2004 (NASA, 2004). Under the selected remedy, NASA will continue to fund operation of the LAWC system and will work closely with the City of Pasadena to install and fund operation of a new centralized treatment system to treat groundwater pumped from four drinking water wells located near the Arroyo Seco (Arroyo Well, Well 52, Ventura Well, and Windsor Well). The two alternatives that were identified for further evaluation include:

- No further action (NFA) – This alternative involves no treatment or remediation of the groundwater. It is included as a baseline for comparison

- Centralized treatment – This alternative involves pumping groundwater from four drinking water wells owned by the City of Pasadena and located in the mid-plume area (see Figure 4-1), immediately downgradient of JPL near the Arroyo Seco. The water pumped from the four wells would be treated with ion exchange and activated carbon at a treatment facility located on the same property as the Windsor Reservoir, which is also owned by the City of Pasadena. This alternative also involves continuing the operation of the ion exchange and activated carbon system installed at LAWC.

As an alternative to a new centralized treatment system for the City of Pasadena, NASA initially considered installing wells and a treatment system just inside the JPL fence line (i.e., on-facility) and reinjecting the treated water, rather than making it available for drinking water use. This alternative was screened out and not included in the detailed evaluation of alternatives presented in Section 10 because it would not be as effective as centralized treatment in providing containment of the chemical plume, nor would it restore the use of the aquifer in a reasonable timeframe.

Use of centralized treatment at the four City of Pasadena Monk Hill Subarea wells restores the use of the aquifer immediately following construction and permitting. In contrast, groundwater modeling indicates that using on-facility extraction and injection to address the mid-plume area would result in the area of the aquifer between the JPL fence line and the LAWC wells having chemical concentrations above cleanup levels for more than a decade after initiating treatment. This is due to the natural groundwater flow, which prevents on-facility extraction and reinjection from being able to remove the plume in the area beneath the Arroyo Seco and West Altadena. That would leave only the LAWC system to contain this large plume.

Historically, the four City of Pasadena wells in the Monk Hill Subarea have provided as much as 10 million gallons of water per day (i.e., approximately 7,000 gallons per minute). The City typically used these wells during the warmer months when the demand for water is higher.

Therefore, there is a benefit to the community by making these wells available as quickly as possible for the City's use.

Centralized treatment requires aboveground systems to remove the VOCs and perchlorate from the pumped water. Considering the conditions at the site, NASA determined that the best treatment technology for VOCs is LGAC and that the best technology for perchlorate is ion exchange.

The EPA has identified air stripping and LGAC as the best technologies for VOC treatment, referring to these as "presumptive technologies" for aboveground treatment of groundwater containing VOCs (EPA, 1996). The EPA expects either of these technologies to be used for removal of VOCs at "all appropriate sites." LGAC treatment is currently in place and working effectively as part of the existing LAWC treatment system. The City of Pasadena had an air stripping facility to remove VOCs from groundwater, although the wells were later shut down by the City of Pasadena when the perchlorate levels exceeded the public health goal. The air stripping system was removed by the City of Pasadena in December 2006. While both technologies are effective, given the concentrations of VOCs in the groundwater, the use of LGAC would be more cost-effective than air stripping. Also, air stripping alters the water chemistry in such a way that other treatment would need to be added prior to ion exchange to prevent scaling (i.e., residues, corrosion, or fouling), thus increasing treatment complexity and cost.

NASA researched the various technologies available to treat groundwater with dissolved concentrations of perchlorate. A literature review was performed to assess the development status of various biological, physical, chemical, and thermal treatment technologies available to remove perchlorate from groundwater (NASA, 2006e). NASA also conducted a number of pilot tests to determine which technologies are the most appropriate for use at the JPL site. The technologies tested include reverse osmosis, FBR, packed bed reactors, in situ bioremediation, and ion exchange (NASA, 2003a). Based on this testing and evaluation, NASA identified two perchlorate treatment processes that have proven to be effective for full-implementation; these are FBR and ion exchange. Of the two, ion exchange is the only technology that has been implemented for removal of perchlorate from drinking water in California. While FBR technology has been evaluated for drinking water treatment and DHS has provided conditional acceptance of the technology, no facilities have been approved. Additionally, recent developments have increased the effectiveness of perchlorate-selective ion exchange resins, which make ion exchange less costly than FBR at the relatively low perchlorate concentrations present in OU-3 groundwater. Based on this, ion exchange is the most appropriate technology for removing perchlorate from groundwater.

The centralized treatment alternative is compared against the NFA alternative in the following sections.

9.1 Alternative 1: No Further Action

9.1.1 Description of Remedy Components

The NFA alternative includes no centralized treatment or containment activities to remediate chemicals in off-facility groundwater. However, this alternative does include continuing the groundwater monitoring program currently in place at JPL. As part of the NFA alternative, the results of the monitoring program are used to characterize concentration levels and the extent of chemicals in groundwater over time. The concentrations and extent of chemicals in groundwater may decrease gradually over time due to natural processes of chemical or physical transformation, sorption, and/or dilution.

9.1.2 Common Elements and Distinguishing Features

Groundwater monitoring would be the component of the NFA alternative; therefore, this alternative is not likely to meet chemical-specific ARARs for OU-3, nor help the final remedy achieve chemical specific ARARs. The NFA alternative would not likely be effective over the long term or meet the remedial action objectives for OU-3 in a reasonable timeframe because chemicals in the groundwater are not removed. Section 12.2 includes a detailed discussion of ARARs for OU-3.

Operation and maintenance (O&M) present worth costs for the groundwater monitoring program are estimated at approximately $8,498,700. It is assumed that the groundwater monitoring will continue for the next 20 years. The projected groundwater monitoring costs are based on actual costs incurred during current groundwater monitoring activities. For costing purposes, it is anticipated that groundwater monitoring will be conducted on a quarterly basis for 10 years, at which time sampling frequency would be reduced to semi-annually.

9.1.3 Expected Outcomes

The NFA alternative is not expected to achieve any additional reduction in toxicity, mobility, or volume of chemicals at OU-3. Under the NFA alternative, reductions in chemical concentrations would rely only on natural processes, such as chemical/biological degradation, dispersion, advection, and sorption. The NFA alternative would not remove target chemicals from the aquifer being used by the local community for drinking water, nor would it protect the environment from the additional migration of chemicals in groundwater outside the JPL fence line.

9.2 Alternative 2: Centralized Treatment

9.2.1 Description of Remedy Components

Alternative 2 includes continued operation of the LAWC centralized treatment system (NASA, 2004), and design, construction and operation of a new centralized treatment system to treat groundwater extracted from the City of Pasadena production wells located in the Monk Hill

Subarea (Arroyo Well, Well 52, Windsor Well and Ventura Well). The treatment system would be installed in the Windsor Reservoir (see additional discussion in Section 9.3) and the treated groundwater would be pumped into the Windsor Reservoir prior to drinking water use.

The LAWC system operates at approximately 2,000 gallons per minute (gpm), with roughly equal portions of flow coming from each production well (LAWC#3 and LAWC#5). Historic operational data were used to estimate the flowrates from each of the four City of Pasadena production wells located within the Monk Hill Subarea. Based on these data, the Arroyo Well, Well 52, Windsor Well, and Ventura well will operate at 2,200 gpm, 1,800 gpm, 1,400 gpm, and 1,600 gpm, respectively, for a total flowrate of 7,000 gpm. Ion exchange and LGAC treatment vessels would likely be arranged in a lead/lag configuration. The lead vessel treats groundwater to meet drinking water standards. The treated water then flows through the lag vessel as a factor of safety. Once the lead vessel becomes loaded with chemicals, chemical concentrations will begin to break through in the lead vessel effluent water (these chemical concentrations will be removed by the lag vessel). At that time, the filter media in the lead vessel will be replaced.

Alternative 2 requires that treated groundwater be incorporated into the Windsor Reservoir to supplement the water supply for the City of Pasadena. Therefore, a centralized treatment system treating groundwater for drinking water use would require disinfection treatment processes that are used to treat municipal water supplies. Disinfection treatment for the City of Pasadena treatment system will include modifying the existing gas chlorine disinfection system at the Windsor Reservoir and introducing ammonium hydroxide (liquid ammonia) to produce chloramines. The treated water will be disinfected prior to discharging into Windsor Reservoir. These chemicals will be managed by the City of Pasadena and will be used to treat drinking water prior to public distribution. Currently, piping connects the Arroyo Well, Well 52, Windsor Well and Ventura Well to the Windsor Reservoir. Additional pipeline installation (approximately 300 ft) will be isolated within the Windsor Reservoir site boundaries.

Centralized treatment for the City of Pasadena production wells would be implemented in conjunction with the continued funding of centralized treatment for LAWC and continuation of the groundwater monitoring program at JPL.

9.2.2 Common Elements and Distinguishing Features

Alternative 2 would meet all chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) and applicable requirements for the City of Pasadena and LAWC by removing VOCs and perchlorate from the drinking water and reducing the toxicity, mobility, and volume of chemicals in groundwater. Ion exchange would remove perchlorate, and LGAC would be used to remove VOCs. Spent filter media would be disposed of by a licensed, commercial waste management firm in accordance with the CERCLA off-site rule (40 Code of Federal Regulations [CFR] 300.440).

Centralized treatment includes using the treated groundwater to supplement the water supply for the City of Pasadena and LAWC. Therefore, California DHS will be involved to ensure that treated groundwater meets all drinking water requirements.

Capital costs for the City of Pasadena treatment system are estimated at approximately $3,171,400 (assuming a 7,000 gpm system). O&M costs are estimated at approximately 3,080,900 annually. Annual O&M costs for the LAWC treatment system are approximately $923,500. The total present worth cost for Alternative 2 is $68,397,000, which includes continued groundwater monitoring and is discussed in Section 10.8.

9.2.3 Expected Outcomes

A treatment system using ion exchange and LGAC is currently operating at LAWC (NASA, 2004). This system has been effective in removing perchlorate and VOCs from pumped water, meeting all federal and state drinking water standards. Therefore, ion exchange and LGAC would be expected to effectively treat perchlorate and VOCs in groundwater extracted from the City of Pasadena Monk Hill Subarea production wells. Based on this information, it is expected that implementation of Alternative 2 would achieve the remedial action objectives by removing target chemicals from the aquifer being used by the local community (LAWC and the City of Pasadena) for drinking water and protecting the environment from the additional migration of chemicals in groundwater outside the JPL fence line. This alternative includes two centralized treatment plants which will allow for immediate drinking water use of the groundwater in the Monk Hill Subarea. Groundwater modeling has suggested that complete restoration of the groundwater in OU-3 will take approximately 18 years with this alternative.

9.3 City of Pasadena Treatment System Location

NASA identified the Windsor Reservoir site as the preferred location of the City of Pasadena treatment system in the Proposed Plan (NASA, 2006b). Based on comments received on the Proposed Plan, NASA issued a Technical Memorandum presenting an evaluation of all locations considered for the City of Pasadena treatment system (NASA, 2006c). NASA considered the following six locations (see also Figure 9-1) for centralized treatment of groundwater extracted from the four City of Pasadena Monk Hill Subarea wells:

- Location 1: Behner Surface Water Treatment Facility
- Location 2: JPL East Parking Lot
- Location 3: Windsor Reservoir
- Location 4: Former Air Stripping Treatment Facility
- Location 5: JPL South Parking Lot
- Location 6: Sheldon Reservoir.

The six locations were evaluated using the nine criteria required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), described in more detail in Section 10 and Section 3.2 of the Responsiveness Summary (Part III of this Interim ROD). Because the same technologies would be used regardless of the site locations, Reduction of Toxicity, Mobility, or Volume of Contaminants would not vary by site location. Therefore, the evaluation of the preferred location depends on Long-Term Effectiveness, Short-Term Effectiveness, Implementability, Cost, and Community Acceptance. These criteria are explained below as they relate to the evaluation of locations.

Long-term effectiveness addresses the risk associated with the implementation of the remedial alternative and the length of time until protectiveness is achieved.

Short-term effectiveness addresses how well human health and the environment are protected from impacts during the construction and system installation activities:

- Protection of community during construction activities
- Protection of workers during construction activities
- Construction duration
- Truck traffic (considering traffic during construction and operation)
- Noise and air quality (during construction and operation)
- Environmental impacts (e.g., to the Arroyo Seco, which is a sensitive ecological area).

Implementability of the treatment facility location addresses the technical and administrative feasibility of implementing an alternative, including:

- Zoning
- Size of property
- Location of property in relation to existing utilities (piping, electrical, etc.)
- Truck traffic during operation
- Ease of construction
- Ease of operation and maintenance
- Ease of undertaking additional remedial actions (if necessary)
- Natural, historical, archeological resources
- Coordination with other agencies.

Cost of the treatment facility is addressed in the following categories:

- Construction
- O&M.

Community Acceptance deals with the general concerns of the local community in relation to the existence of the treatment plant in the community.

Following the June 21, 2006, public meeting in which NASA presented its evaluation of potential locations for the City of Pasadena system, NASA contacted the City of Pasadena personnel associated with the Hahamongna Watershed Park regarding construction within the Arroyo Seco. In general, construction within the Arroyo Seco is not consistent with the goals of the City Council-approved Master Plans (Pasadena, 2006b). Some of the primary goals include preserving, restoring, and enhancing natural habitat in the Arroyo Seco, providing flood control, and maximizing groundwater recharge via spreading basins. These goals limit the ability to construct treatment systems in the Arroyo Seco, including at Location 2 (JPL East Parking Lot) and Location 4 (Former Air Stripping Treatment Facility).

The Master Plan would require that the large pipeline construction from the City of Pasadena wells to the JPL facility associated with Location 5 (JPL South Parking Lot) be constructed along approved utility corridors, which includes crossing the Arroyo near the northern end of the Watershed Park (i.e., near the existing bridge to JPL). Crossing the Arroyo Seco at this location

would require an additional 4,000 ft of pipeline installation (above what was evaluated in the Technical Memorandum (NASA, 2006c), resulting in additional construction time (1 to 2 months), increased difficulty of implementation due to working around other utilities, and increased cost of approximately $2,000,000.

Pipeline construction activities associated with all of the locations other than Location 3 (Windsor Reservoir) and Location 4 (Former Air Stripping Treatment Facility) would be intrusive, requiring a crew size of approximately 15 and significant heavy equipment (two large track hoes, two smaller back hoes, two dump trucks, a water truck, and two or more general service vehicles). In addition, a considerable amount of traffic control would be required along Windsor Avenue and/or JPL parking lots, including traffic cones and sign workers at either end of the construction zone.

Table 9-1 presents an overview of the distinguishing features identified for each location as part of this evaluation. Based on the evaluation, the Windsor Reservoir site is considered the preferred location, as it offers the best balance of long-term effectiveness, short-term effectiveness, implementability, and cost.

Based on written and verbal comments from the community relative to the Windsor Reservoir location, NASA and the City of Pasadena are examining options to reduce noise and improve aesthetics, including landscaping and engineering controls (such as acoustical materials to decrease sound, lowering the system's foundation below grade to decrease visibility, and the vendor's ability to reduce impacts to the surrounding community). Additional details regarding the responses of NASA and the City of Pasadena to public concerns are presented in Section 3.0 of the Responsiveness Summary (Part III of this Interim ROD).

Figure 9-1. Aerial Photograph Showing Six Areas Near Arroyo Seco Considered as Locations for the City of Pasadena Groundwater Treatment Facility

Table 9-1. Evaluation Summary for the Location of the City of Pasadena System

Location	Long-Term Effectiveness	Short-Term Effectiveness	Implementability	Cost	Community Acceptance
1. Behner Surface Water Treatment Facility	• The system would be designed, operated, and monitored to ensure safety to the surrounding community. • Site has served in the past as the location for a surface water treatment plant.	• The existing treatment plant would need to be demolished. • Impacts would be minimized by adhering to safe construction practices and City of Pasadena requirements for work hours, traffic control, noise, and dust control. • Approximately 1 mile of new piping would be required to transfer water to the facility and then back to Windsor Reservoir.	• Limited space for construction staging and any addition to the treatment plant. • Major improvements to the narrow, winding forest service road would be required to accommodate construction equipment and truck deliveries. • A new treatment facility on this location is incompatible with the City of Pasadena's planned use of this property.	• The estimated construction cost for this location is $7.0M. • The O&M cost is estimated to be $3.2M per year. • O&M costs include energy costs for transfer of water to the plant and back to Windsor Reservoir.	• Residential areas are located approximately 200 feet east of this location. • Bicycle and jogging trails would not be available during the construction and delivery times.
2. JPL East Parking Lot	• The system would be designed, operated, and monitored to ensure safety to the surrounding community.	• The entrance to the JPL East Parking Lot would need to be modified. • Impacts would be minimized by adhering to safe construction practices and City of Pasadena requirements for work hours, traffic control, noise, and dust control. • Approximately 2,500 ft of new piping would be required to transfer water to the facility and then back to Windsor Reservoir.	• The required electrical power would need to be routed by installing additional overhead wiring and transformer banks. • The zoning category for this site (Open Space) would allow construction of a treatment facility. • Construction within the Arroyo Seco is not consistent with the goals of the City Council-approved Master Plans.	• The estimated construction cost for this location is $5.1M. • The O&M cost is estimated to be $3.1M per year. • Costs would include design, 2,500 feet of new pipeline installation, site preparation, plant construction, mechanical systems installation, associated electrical work, and landscaping.	• Residential areas are located approximately 300 feet east of this location.
3. Windsor Reservoir	• The system would be designed, operated, and monitored to ensure safety to the surrounding	• Impacts would be minimized by adhering to safe construction practices and City of Pasadena requirements for work hours, traffic control, noise, and dust control. • A limited amount (300 ft) of	• The required electrical power is already present onsite. • The zoning category for this site (Public Space) would allow construction of a treatment facility. • The site has available space	• The estimated construction cost for this location is $3.2 M. • The O&M cost is estimated to be $3.1M per year. • Costs would include	• Residential areas are located approximately 50 feet from this location. • Members of the

Location	Long-Term Effectiveness	Short-Term Effectiveness	Implementability	Cost	Community Acceptance
	community.	new piping would be required to transfer water to the facility and then back to Windsor Reservoir.	that could be used as a staging area during construction.	design, 300 feet of new pipeline installation, site preparation, plant construction, mechanical systems installation, associated electrical work, and landscaping.	community have expressed concerns about noise, aesthetics and safety-related issues.
4. Former Air Stripping Treatment Facility	• The system would be designed, operated, and monitored to ensure safety to the surrounding community.	• Impacts would be minimized by adhering to safe construction practices and City of Pasadena requirements for work hours, traffic control, noise, and dust control. • Environmental impacts to the Arroyo Seco would be significant due to construction within the Arroyo Seco. • Approximately 300 ft of new piping would be required to transfer water to the existing pipeline.	• No additional space for construction staging and any addition to the treatment plant. • Major improvements to Auzenne Avenue would be required to accommodate construction equipment and truck deliveries. • The zoning category for this site (Open Space) would allow construction of a treatment facility. • The required electrical power would need to be routed by installing additional overhead wiring and transformer banks. • Construction within the Arroyo Seco is not consistent with the goals of the City Council-approved Master Plans.	• The estimated construction cost for this location is $5.2 M. • The O&M cost is estimated to be $3.1M per year. • Costs would include design, 300 feet of new pipeline installation, 1,000 feet of retaining wall, site preparation, plant construction, mechanical systems installation, associated electrical work, and landscaping.	• Residential areas are located approximately 200 feet east of this location. • Environmental groups would likely oppose construction in the Arroyo Seco.
5. JPL South Parking Lot	• The system would be designed, operated, and monitored to ensure safety to the surrounding community.	• Impacts would be minimized by adhering to safe construction practices and City of Pasadena requirements for work hours, traffic control, noise, and dust control. • Environmental impacts to the Arroyo Seco would be	• The zoning category for this site (Planned Development) would allow construction of a treatment facility. • The required electrical power would need to be routed by installing additional overhead wiring and transformer banks.	• The estimated construction cost for this location is $7.1M ($9.1M assuming installation along the utility corridor). • The O&M cost is estimated to be $3.1M per year.	• Environmental groups would likely oppose construction in the Arroyo Seco. • During the May and June 2006

Location	Long-Term Effectiveness	Short-Term Effectiveness	Implementability	Cost	Community Acceptance
		significant due to pipeline installation within the Arroyo Seco. • Approximately 6,000 ft of new piping would be installed across the Arroyo Seco, 10,000 ft of new piping assuming installation along the utility corridor.	• Construction within the Arroyo Seco is not consistent with the goals of the City Council-approved Master Plans. • Construction is complicated by working around a high density of other utilities, which are located along the utility corridor at the north end of the Arroyo Seco.	• Costs would include design, 6,000 feet of new pipeline installation (10,000 ft for installation along the utility corridor), site preparation, plant construction, mechanical systems installation, associated electrical work, and landscaping.	public meetings, some members of the community expressed preference for this location.
6. Sheldon Reservoir	• The system would be designed, operated, and monitored to ensure safety to the surrounding community.	• Impacts would be minimized by adhering to safe construction practices and City of Pasadena requirements for work hours, traffic control, noise, and dust control. • Approximately 2 miles of new piping would be installed across the 210 Freeway.	• The zoning category for this site (Single Family Residence) would make it difficult to gain approval from the City of Pasadena. • The required electrical power would need to be routed by installing additional overhead wiring and transformer banks. • Construction activities would be difficult to a shortage of space for staging.	• The estimated construction cost for this location is $9.1 M. • The O&M cost is estimated to be $3.2M per year. • Costs would include design, 10,000 feet of new pipeline installation, site preparation, plant construction, mechanical systems installation, associated electrical work, and landscaping.	• Residential areas are located approximately 50 feet from this location. • Members of the community would likely have concerns about noise, aesthetics and safety related issues.

10.0: SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Nine evaluation criteria were developed by the EPA under the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300) for evaluation of remedial action alternatives. The alternatives are evaluated against these criteria. The nine criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria, as follows:

Threshold Criteria

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume of Contaminants
- Short-Term Effectiveness
- Implementability
- Cost

Modifying Criteria

- State Acceptance
- Community Acceptance.

The threshold criteria must be satisfied in order for an alternative to be eligible for selection. The primary balancing criteria are alternatives to weigh major tradeoffs between alternatives. The modifying criteria are evaluated after the lead agency (in this case, NASA) receives and reviews all public comments received during the public comment period.

10.1 Comparison of Remedial Alternatives Using Evaluation Criteria

This section uses the nine evaluation criteria to compare and evaluate the response action alternatives for off-facility groundwater. Table 10-1 summarizes the screening results of the two alternatives evaluated for OU-3: 1) Alternative 1: NFA and 2) Alternative 2: centralized treatment.

10.2 Protection of Human Health and the Environment

This criterion assesses whether an alternative provides adequate public health and environmental protection, and describes how health and environmental risks posed by the site will be eliminated, reduced, or controlled through treatment, engineering controls, or other means.

Table 10-1. Summary of the Comparative Analysis of Remedial Alternatives Evaluated for OU-3

Criteria	Alternative 1: No Further Action	Alternative 2: Centralized Treatment
Overall Protection	• Not protective of environment	• Short- and long-term protection of the environment by reducing VOC and perchlorate concentrations in groundwater and preventing further migration
Compliance with ARARs	• Location- and action-specific ARARs are not triggered • Does not support the final remedy in achieving chemical specific ARARs	• Complies with action- and location-specific ARARs • Provides benefit to the final remedy in achieving chemical-specific ARARs
Long-Term Effectiveness and Permanence	• Not effective in long-term • VOCs and perchlorate remain in groundwater and could migrate to off-facility areas	• Effective in long-term • Permanent removal of perchlorate and VOCs from groundwater • Continuous pumping provides long-term hydraulic control
Reduction of Toxicity, Mobility, or Volume	• No reduction in mobility or volume of VOCs or perchlorate	• Reduces mobility and mass of VOCs and perchlorate through treatment • Provides hydraulic control to prevent migration
Short-Term Effectiveness	• Not effective in short-term • VOCs and perchlorate will remain in groundwater and continue to migrate • Drinking water usage of groundwater in the Monk Hill Subarea will not be restored	• Effective in the short-term • Does not present substantive risks to the community • Allows for immediate use of groundwater in the Monk Hill Subarea by the City of Pasadena as a drinking water source
Implementability	• Easily implemented	• Technologies are proven to be effective and are readily available • Existing production wells would be used for extraction • Requires a relatively complex permitting effort by the City of Pasadena
Cost	• Approximate cost: $8,498,700	• Approximate cost: $68,397,000
Conclusion	• Does not meet remedial action objectives and is not protective of the environment	• Selected Remedy • Meets all of the remedial action objectives and allows immediate use of groundwater

The only exposure pathway to the OU-3 groundwater is through pumping from drinking water wells located off-facility. Currently, these production wells are either shut down or the pumped groundwater is treated prior to water distribution to customers, thus preventing a direct exposure pathway. The scoping assessment of ecological risks concluded that no complete pathway exists for ecological exposure to the untreated groundwater and there are no significant ecological risks. Based on these assessments, Alternative 1 (NFA) and Alternative 2 (centralized treatment) are protective of human health because there is no potential for exposure to untreated groundwater. Alternative 1 does not remove VOCs and perchlorate from the aquifer or prevent migration of chemicals outside the JPL fence line and is therefore not protective of groundwater or the environment. Alternative 2 reduces VOC and perchlorate mass in the groundwater and prevents the further migration of chemicals, thereby protecting the environment. Alternative 2 involves meeting applicable, relevant, or appropriate state and federal water quality requirements prior to distribution to consumers and are therefore protective of human health.

10.3 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs addresses whether a remedial action alternative meets all pertinent federal and state environmental statutes and requirements. An alternative must comply with ARARs or be covered by a waiver to be acceptable. Section 12.2 of this document contains an evaluation of ARARs that apply to the response action for OU-3.

Alternative 1 (NFA) does not trigger location- and action-specific ARARs, but does not support the final remedy in meeting chemical-specific ARARs because groundwater at JPL is not protected. Alternative 2 (centralized treatment) meets all location- and action-specific ARARs, prevents further migration of VOCs and perchlorate, and removes chemical mass from the aquifer, thus supporting the final remedy.

10.4 Long-Term Effectiveness and Performance

Long-term effectiveness addresses the ability of an alternative to maintain reliable protection of human health and the environment over time, including the degree of certainty that the alternative will prove successful.

Alternative 1 (NFA) is not effective over the long term, because no additional remediation is provided to prevent the migration of chemicals in groundwater. In the absence of treatment, reduction in the concentrations and extent of chemicals in groundwater would rely on slow, natural processes of chemical or physical transformation, sorption, and/or dilution.

Alternative 2 (centralized treatment) would be effective over the long term. This alternative provides treatment to permanently remove VOCs and perchlorate from groundwater and would be effective over the long term through an overall reduction in chemical concentrations in groundwater. The treatment technologies (ion exchange and LGAC) have proven to be effective in treating groundwater to standards or goals required by the state and federal government. The treatment system itself will not result in any longer term impacts from its operation. The used LGAC and ion exchange resin would be safely removed and replaced using specialized equipment and trucks.

Because the City of Pasadena intends to use the treated water for drinking water purposes, the City will disinfect the water prior to distribution, as is done for all public water systems. Disinfection of drinking water requires the use of certain chemicals. The supply for these chemicals will be trucked to the site. All federal and state requirements would be followed in handling and storage of these chemicals to prevent spills, including separate, fully-enclosed, fully-contained tanks equipped with leak detection devices.

Under Alternative 2 it is estimated that active treatment would be required for approximately 18 years. The proposed technologies and equipment have proven to be effective over an 18-year duration. Additionally, Alternative 2 involves an aspect of hydraulic control which will meet the remedial action objective of preventing migration of facility-related chemicals of interest in groundwater.

10.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The evaluation of this criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies for permanently and significantly reducing toxicity, mobility, and volume of chemicals in groundwater. VOCs and perchlorate are present in deep groundwater and production wells are either turned off or treated; therefore, there is currently no exposure pathway for any receptor on or off the JPL facility.

Alternative 1 (NFA) is not effective in reducing the toxicity, mobility, or volume of chemicals of concern under this alternative, because no active treatment would be implemented.

Alternative 2 (centralized treatment) provides treatment to reduce the toxicity, mobility, and volume of chemicals in groundwater. The treatment processes remove perchlorate and VOCs through adsorption onto media. The used media will then be disposed of in accordance with federal and state requirements. Alternative 2 includes pumping up to 2,000 gpm and 7,000 gpm of groundwater from the LAWC and City of Pasadena drinking water wells, respectively, which will provide hydraulic control to prevent migration of chemicals in groundwater.

10.6 Short-Term Effectiveness

The evaluation of short-term effectiveness addresses how well human health and the environment are protected from impacts during the construction and implementation of a remedial alternative, and the length of time until protectiveness is achieved.

Alternative 1 (NFA) is not effective over the short term because no active remediation would be implemented to address chemical concentrations in groundwater and, as a result, chemicals in the groundwater would continue to migrate. Further, drinking water wells owned by the City of Pasadena and LAWC in the Monk Hill Subarea would be unavailable for use.

Alternative 2 (centralized treatment) will be effective over the short-term. The LAWC treatment system is already operating, so there are no short-term effectiveness issues with that facility. The

Windsor Reservoir is located in the middle of a residential area and the construction activities will have some effect on neighbors living in the vicinity of the site, including truck traffic, noise, and dust. The impacts will be minimized by adhering to City of Pasadena requirements for construction hours, traffic control, noise, and dust control. Construction activities will last approximately three to four months, assuming no interruptions. Because this location is adjacent to the Windsor Reservoir (the distribution point for the treated water), a very limited amount of pipeline installation is required, only about 300 feet within the Windsor Reservoir property. Truck traffic will increase on Windsor Avenue during the construction period and during O&M. As part of the system O&M, three to four deliveries of LGAC and/or ion exchange resin per month are expected. All used media (e.g., used LGAC and resin) will be transported and disposed of in accordance with state and federal regulations.

Centralized treatment will allow the immediate use of groundwater as a drinking water source. Ion exchange and LGAC have been widely implemented in the past for drinking water treatment (to treat perchlorate and VOCs, respectively); therefore, each is an established technology that has gained acceptance from federal and state agencies. Ion exchange and LGAC are proven technologies with minimal startup issues and are able to supply clean water almost immediately upon installation as demonstrated by the LAWC plant.

10.7 Implementability

Evaluation of implementability addresses the technical and administrative feasibility of implementing an alternative, including an evaluation of the availability of technologies, services, and materials required during implementation.

Alternative 1 (NFA) is easily implemented. The equipment and methods used for groundwater sampling and analysis are commercially-available and currently in use.

Implementation of Alternative 2 would require a relatively complex permitting effort by the City of Pasadena, including obtaining a Conditional Use Permit from the City's Planning Department for land use, conducting a California Environmental Quality Act (CEQA) evaluation, obtaining a Building Permit, and obtaining a permit to operate from the DHS including compliance with DHS Policy Memorandum 97-005. The City of Pasadena strongly supports the centralized treatment alternative and Pasadena Water and Power is the City Department that will coordinate the effort with the other technical and permitting departments within the city. The Windsor Reservoir has the appropriate zoning (Public Space) for construction of a treatment facility. In addition, because the pipelines to the Windsor Reservoir are in place, Alternative 2 would only require the installation of the treatment system and some ancillary piping within the boundaries of the Windsor Reservoir site. Alternative 2 would also include rehabilitation work on the existing drinking water wells (three of which are located outside the Windsor Reservoir site) and upgrading the well electrical equipment.

The Windsor Reservoir site will easily accommodate the 150 feet by 100 feet concrete pad needed for the system. In addition, space would be available for use as the staging area to be used temporarily (three to four months) for construction activities. Required electrical power already exists in the area so none would need to be constructed. Adequate piping for delivery of

the extracted water from Arroyo Well, Well 52, Windsor, and Ventura well to the site already exists. Only limited construction of a 24-inch-diameter pipeline (approximately 300 feet) within the open area of the site (to the west of the reservoir) would be required to connect the new treatment system to the existing pipelines and the Windsor Reservoir. After starting system operation, trailer trucks would deliver the LGAC, ion exchange filter media and the disinfection chemicals to the site on a regular basis during O&M. Though this traffic would impact the Windsor Avenue area south of the Windsor Reservoir, deliveries during peak traffic times (during the morning and evening rush hour) will be minimized. Near the site, Windsor Avenue is sufficiently wide to accommodate trucks access to the site safely outside the flow of traffic.

10.8 Costs

Evaluation of cost addresses the total cost of the remedial action, including capital costs and O&M costs. A summary of the present-worth costs associated with the response action alternatives for OU-3 is presented in Table 10-2. The only costs associated with Alternative 1 (NFA) correspond to the continuation of the groundwater monitoring program at JPL for 20 years, which results in a total cost of $8,498,700.

Costs associated with Alternative 2 (centralized treatment) include installation of a 7,000 gpm LGAC and ion exchange system, production well rehabilitation, system design, and associated permitting associated with the four City of Pasadena Monk Hill Subarea production wells. O&M costs for both the City of Pasadena and LAWC treatment systems include activated carbon change-outs, ion exchange resin change-outs, system operation, system maintenance, sample analysis, and regulatory fees. Continued groundwater monitoring is also included.

The costs presented in Table 10-2 for Alternative 2 correspond to an 18 year operation period for the City of Pasadena treatment system. The estimated construction cost for the treatment system is $3,171,400; the annual O&M costs are approximately $3,080,900. Costs for continued groundwater monitoring for 20 years and continued funding of the LAWC treatment system for 18 years are $8,498,700 and $13,082,400, respectively. The total cost for implementing Alternative 2 is $68,397,000 which includes all aspects of this approach over the next 20 years.

Table 10-2. Comparison of Cost Estimates for Alternatives 1 and 2

Description	Capital Costs	Annual O&M Costs	Total Cost
Alternative 1: No Further Action			
Groundwater Monitoring (year 1 to 10)	0	$684,000	$8,498,700
Groundwater Monitoring (year 11 to 20)	0	$380,700	
Total Cost for Alternative 1:			**$8,498,700**
Alternative 2: Centralized Treatment			
Groundwater Monitoring (year 1 to 10)	0	$684,000	$8,498,700
Groundwater Monitoring (year 11 to 20)	0	$380,700	
LAWC System Operation	0	$923,500	$13,082,400
Centralized Treatment	$3,171,400	$3,080,900	$46,815,900
Total Cost for Alternative 2:			**$68,397,000**

(a) Costs are estimated to the nearest $100.
(b) Total costs are estimated at present-worth value, assuming 18 years for system operation, 20 years of groundwater monitoring and a 3% discount rate.
(c) Monitoring costs have been presented separately for years 1 to 10 and years 11 to 20. This has been done because it is likely that monitoring activities will transition from a quarterly basis to a semi-annual basis. The total cost for monitoring has been merged; this present-worth cost has been calculated assuming that the monitoring program will transition from quarterly to semi-annual sampling after approximately 10 years.

10.9 State Acceptance

The state acceptance criterion requires that NASA, as the lead agency, addresses the state's comments and concerns for each proposed alternative. RWQCB and DTSC approved the *Proposed Plan To Fund Construction and Operation of Treatment Systems for Groundwater from Drinking Water Wells Located near the National Aeronautics and Space Administration's Jet Propulsion Laboratory* (NASA, 2006b). This document specified that centralized treatment (Alternative 2) for groundwater from the City of Pasadena's production wells (with the treatment plant located at the Windsor Reservoir site), continued funding of the LAWC treatment system, and continued groundwater monitoring was the preferred alternative.

10.10 Community Acceptance

NASA carefully evaluated all public comments, taking into consideration information provided by the public. Part III of this Interim ROD documents the comments that NASA received from the public regarding the preferred alternative to construct a centralized treatment plant at the Windsor Reservoir, as well as NASA's responses to those comments. Community members were, for the most part, in agreement that treatment was needed and that centralized treatment, which results in immediate use of the groundwater, was preferred. There were comments and questions during the public comment period for the Proposed Plan. NASA is currently taking action to address a number of these public concerns.

One of the primary public concerns was the location of a new treatment system at the Windsor Reservoir site. NASA issued a Technical Memorandum following the public meeting that presented an *Alternatives Evaluation for the City of Pasadena Treatment Plant* (NASA, 2006c). NASA considered a number of locations (see Section 9.3) for centralized treatment of groundwater extracted from the four City of Pasadena Monk Hill Subarea wells and determined that the Windsor Reservoir site is the preferred location, as it offers the best balance of long-term effectiveness, short-term effectiveness, implementability, cost, and community acceptance.

Public concerns associated with constructing the City of Pasadena treatment plant at the Windsor Reservoir include noise, aesthetics and safety. In response to these concerns NASA and the City of Pasadena are examining options to reduce noise and improve aesthetics, including landscaping and engineering controls (such as acoustical materials to decrease sound, engineered options to decrease visibility, and the vendor's ability to reduce impacts to the surrounding community, which was included as part of the evaluation criteria for selection of a vendor). Additional details regarding the responses of NASA and the City of Pasadena to public concerns are presented in Section 3.0 of the Part III of this Interim ROD.

11.0: THE SELECTED REMEDY

Based on the comparative analysis of the response action alternatives (Section 10), the selected remedy for addressing OU-3 is Alternative 2, which includes funding the construction and operation of a centralized treatment system for the City of Pasadena to remove concentrations of perchlorate and VOCs using ion exchange and LGAC. In addition, Alternative 2 involves continued funding of the LAWC treatment system and continued groundwater monitoring at JPL. NASA, EPA, DTSC, and RWQCB agree with the selection of this alternative as the appropriate response action for OU-3.

11.1 Rationale for the Selected Remedy

NASA will remove target chemicals (see Table 5-1) from the aquifer at four City of Pasadena drinking water wells by adding a treatment facility to remove perchlorate and VOCs and continue funding a treatment plant for two LAWC wells. This approach is referred to as centralized treatment because groundwater pumped from the multiple wells is treated at a central location prior to use by City of Pasadena and LAWC customers. This combined alternative (i.e., the two centralized treatment systems) is selected by NASA because it would support the final remedial outcome of removing the target chemicals from the groundwater in an aquifer being used by the local community (i.e., LAWC and the City of Pasadena) for drinking water and will protect the environment from the additional migration of chemicals in groundwater outside the JPL fence line. In addition, treatment allows for the immediate use of groundwater as a drinking water source, thereby restoring the beneficial use of the aquifer.

11.2 Description of the Selected Remedy

In this approach, NASA will continue to fund the existing treatment system constructed in 2004 at the LAWC (NASA, 2004), as well as continue groundwater monitoring activities.

In addition, NASA will directly administer some of the work associated with designing, permitting, and constructing the new City of Pasadena treatment system. The system will be located adjacent to the Windsor Well and Windsor Reservoir (see Figure 11-1) (NASA, 2006c). The City of Pasadena will be funded by NASA to lease treatment equipment and operate the system. Groundwater from four City of Pasadena drinking water wells – Arroyo Well, Well 52, Windsor Well, and Ventura Well – will be cleaned in this new treatment facility using an LGAC system to remove VOCs, and an ion exchange system to remove perchlorate (see Figure 11-2).

A team of landscape architects is developing landscaping options to improve the aesthetics at Windsor Reservoir. These efforts involve developing a conceptual plan for the appearance of the site, including specific plant types and drawings of how various landscaping approaches might appear from Windsor Avenue and the surrounding neighborhood. These drawings will likely include a winding walkway, newly planted shrubs, and additional trees along the Windsor frontage. Prior to installation, these details will be available for meetings with local residents. The City of Pasadena intends to discuss the landscape plan with residents, and receive resident input on their preferences and plant selections.

A traffic management plan will be an integral component of the project planning phase. The traffic management plan will include timing truck traffic to minimize the impacts to the neighborhood. Other measures will include adequate signage, a traffic monitor, and potential alterations to the roadway near the access to the site. Project-related traffic will travel down Windsor Avenue during construction.

A reduction in noise levels will be a priority design consideration during the planning stages of the project. Acoustical controls will be used to mitigate and minimize noise resulting from the system so as to reduce impacts to the community. Acoustical controls consist of using materials that absorb sound waves to minimize the noise heard offsite. Most likely, acoustical materials will be used to enclose the sound-generating components of the system. At a minimum, the Monk Hill treatment system will comply with noise standards required by the City of Pasadena. For a residential area, such as the Windsor Reservoir site, operational noise levels will comply with the relevant requirement, which are 45 dB between 10 PM and 7 AM and 50 dB between 7 AM and 10 PM. These noise levels are comparable to background noise heard in an urban setting during the day.

The structural components (i.e., piping and vessels) of the system will be designed so that they can sustain forces resulting from seismic activity and inclement weather. In addition, sensors will be incorporated into the system design. These sensors will be used to transmit pertinent operational information during system operation. The sensor network will be programmed so that the system can automatically shut down in the event of any potential problems.

No institutional controls are required for this response action because the only way for the public to come in contact with the groundwater located several hundred feet below the ground surface is through pumping from drinking water production wells located off-facility. These production wells are either shut down or treated prior to water distribution to customers, thus preventing a direct exposure pathway. In addition, the Superior Court of California approved the Raymond Basin Judgment in 1944, which adjudicated the rights to groundwater production to preserve the safe yield of the groundwater basin. Groundwater pumping with the Basin is under the oversight of the Raymond Basin Management Board.

11.3 Estimated Remedy Costs

Table 11-1 presents the estimated capital costs ($3,171,400) for the City of Pasadena treatment system. The term capital cost refers to the funds required to cover the initial nonrecurring costs associated with purchasing and installing the technology to the point where it is ready for its intended use. The capital cost estimate for the treatment system is based on a 7,000 gpm design flowrate. Costs associated with the installation of the treatment system include the purchase of equipment such as pumps, ion exchange vessels, LGAC vessels and piping. The selected remedy involves pumping groundwater from four production wells (Windsor Well, Ventura Well, Well 52, and Arroyo Well) owned by the City of Pasadena. These wells have been offline and will need to be rehabilitated. Waste disposal addresses the disposal of waste generated during the well rehabilitation activities. All management and oversight costs are included in each individual component of the capital cost.

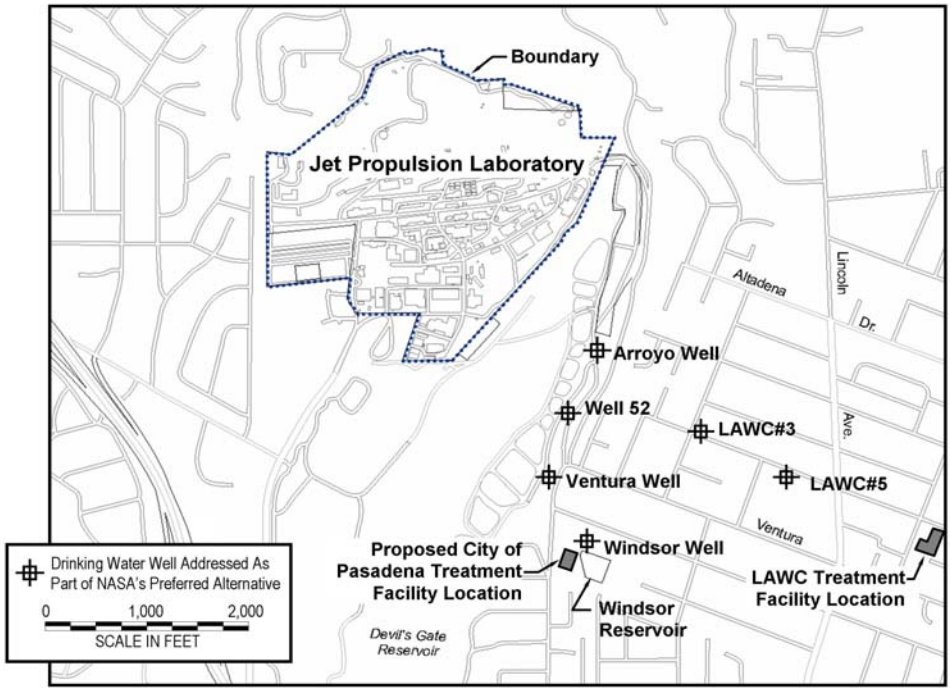


Figure 11-1. Map Depicting the Location of the Windsor Reservoir and the City of Pasadena Production Wells

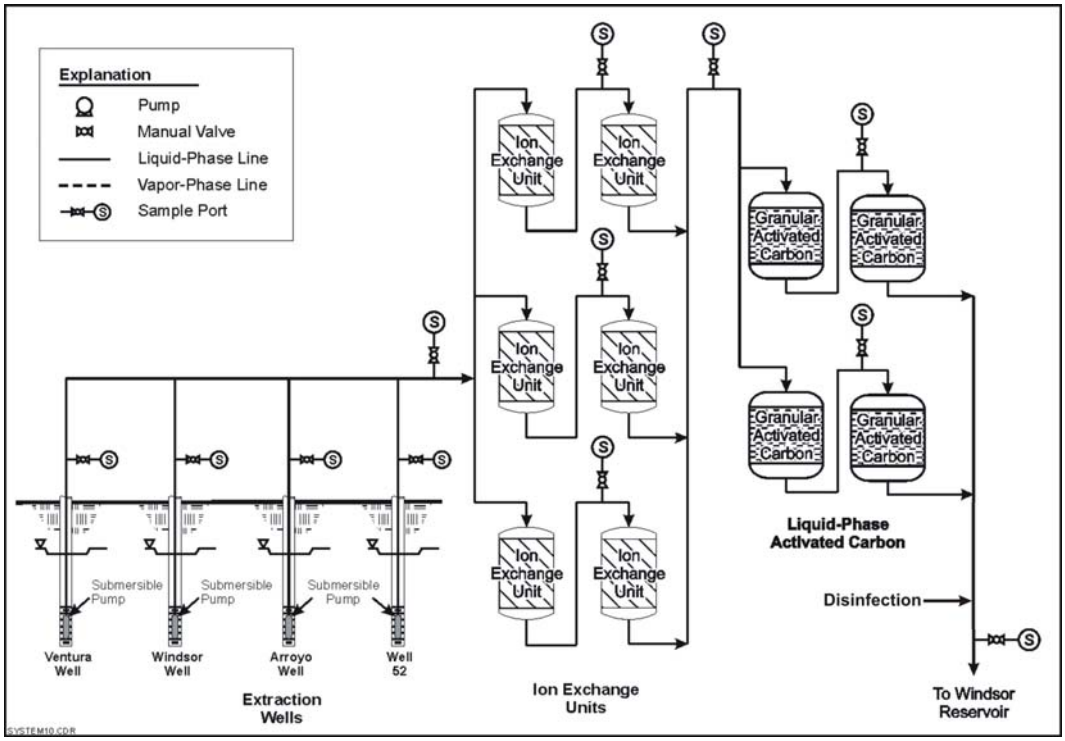


Figure 11-2. Process Flow Diagram for the City of Pasadena Centralized Treatment System

Table 11-1. Estimate of Capital Costs for the Selected Remedy

Description	Cost
Design	$244,000
Construction	$1,398,200
Production Well Rehabilitation	$1,041,300
Oversight and Management	$487,900
Total	**$3,171,400**

The O&M costs for each technology are the recurring or periodic costs incurred during the operating life of the system. Ion exchange O&M costs include labor, equipment rental, ion exchange resin and LGAC replacement costs, electricity, and other expenses. Table 11-2 presents the annual O&M costs ($3,080,900) for the City of Pasadena treatment system.

Table 11-2. Estimate of Annual Operation and Maintenance Costs for the Selected Remedy (City of Pasadena Centralized Treatment System)

Description	Unit	Unit Cost	Quantity	Total Cost
Ion Exchange System				
Fixed Monthly Cost	Month	$20,100	12	$241,200
Treatment Cost	Ac-ft	$182	7000	$1,270,600[(a)]
Liquid Granular Activated Carbon				
Fixed Monthly Cost	Month	$25,200	12	$302,400
Carbon Changeouts	Each	$12,800	42	$537,600
City of Pasadena Administrative Costs				
Administrative Costs	LS	$729,100	1	$729,100
			Total	**$3,080,900**

(a) Total cost has been rounded to the nearest $100.

The present-worth cost of initializing a centralized treatment system for the City of Pasadena is $46,815,900. This value assumes that the capital costs presented in Table 11-1 are needed to construct the system and that the O&M costs presented in Table 11-2 will be incurred for the 18 year operational lifetime of the City of Pasadena treatment system. As shown in Table 11-3, constructing and operating the City of Pasadena centralized treatment system is only one component of the selected remedy for OU-3. Including the continued operation of the LAWC treatment system for the next 18 years and continued groundwater monitoring for the next 20 years, the present-worth total cost is $68,397,000. The term "present-worth" represents the amount of money or principal needed today to cover all of the costs over the lifetime of the remediation project given a specified discount or interest rate, which has been assumed as 3% for costing purposes.

Table 11-3. Present-Worth Estimate of Total Costs for the City of Pasadena Centralized Treatment, Continued Groundwater Monitoring, and Continued Funding of the LAWC Treatment System

Description	Capital Costs	Annual O&M Costs	Total Cost
Groundwater Monitoring (year 1 to 10)	0	$684,000	$8,498,700
Groundwater Monitoring (year 11 to 20)	0	$380,700	
LAWC System Operation	0	$923,500	$13,082,400
City of Pasadena Centralized Treatment System	$3,171,400	$3,080,900	$46,815,900
		Grand Total	**$68,397,000**

(a) Costs are estimated to the nearest $100.
(b) Total costs are estimated at present-worth values, assuming 18 years for system operation, 20 years of groundwater monitoring and a 3% discount rate.
(c) Monitoring costs have been presented separately for years 1 to 10 and years 11 to 20. This has been done because it is likely that monitoring activities will transition from a quarterly to a semi-annual basis. The total cost for monitoring has been merged; this present-worth cost has been calculated assuming that the monitoring program will transition from quarterly to semi-annual sampling after approximately 10 years.

11.4 Expected Outcomes of the Selected Remedy

It is anticipated that the response action will restore the use of these municipal drinking water wells, reduce concentrations of perchlorate and VOCs from groundwater, and prevent further migration of chemicals in the groundwater from the JPL facility. The results of this OU-3 response action will be evaluated along with the results of the OU-1 response action (NASA, 2006f) to assess possible final cleanup remedies for groundwater at JPL.

Performance objectives have been established for the OU-3 response action to achieve the remedial action objectives. The system will be optimized until performance objectives have been achieved. The performance of the system will be evaluated on a continuing basis and the information regarding the amount of VOCs and perchlorate removed will be reported to the regulatory agencies during quarterly status meetings and in annual progress reports to effectively evaluate system performance objectives. The City of Pasadena and LAWC will report, or continue to report, system performance data to DHS on a monthly basis.

The performance objectives include the following:

- Reduction of CCl_4, TCE, PCE, and perchlorate concentrations in the extracted groundwater so that the treated water may be supplied as drinking water to the residents and customers of the City of Pasadena and LAWC. See Table 11-4 for the applicable drinking water standards for these chemicals.

- Operate the LAWC and City of Pasadena centralized treatment systems until CCl_4, TCE, PCE, and perchlorate concentrations in the extracted water are consistently reduced to levels that no longer exceed applicable drinking water standards.

Table 11-4. Summary of Applicable Drinking Water Standards for Target Chemicals

Analyte	Federal MCL (40 CFR § 141.61)	California MCL (CCR Title 22, § 64444)
CCl_4	5	0.5
TCE	5	5
PCE	5	5
Perchlorate	NA	NA[(a)]

(a) An MCL does not exist for perchlorate; however, DHS has established a PHG of 6 µg/L.

CCR = California Code of Regulations

After the performance objectives have been achieved, NASA will no longer fund the OU-3 treatment systems although groundwater monitoring will continue. If rebound of chemical concentrations occurred in the LAWC and City of Pasadena production wells above drinking water standards, NASA would reinitiate funding. When performance objectives have been achieved and it is determined that no rebound of chemical concentrations occurred, NASA would end the funding agreements with the City of Pasadena and LAWC. The City of Pasadena and LAWC may decide to continue treatment; however, it would be an action taken outside the CERCLA process.

Minimal environmental impacts are expected from implementation of the OU-3 response action. Groundwater treatment will have no adverse impacts on threatened or endangered species, cultural resources, floodplains, or wetlands. NASA expects no adverse human health impacts from this action to occur in any community.

12.0: STATUTORY DETERMINATIONS

NASA has decided to undertake a response action at the JPL CERCLA site to achieve protection of human health and the environment. The selected remedy for this site must meet applicable or relevant and appropriate environmental standards as established under federal and state environmental laws, unless a statutory waiver is justified. The selected remedy must also be cost-effective and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the remedy should employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of chemicals in the groundwater. This section provides a brief description of how the selected remedy, centralized treatment at production wells located in the Monk Hill Subarea and owned by the City of Pasadena and LAWC, satisfies the statutory requirements of CERCLA.

12.1 Protection of Human Health and the Environment

Groundwater with aqueous concentrations of perchlorate and VOCs is located over 250 ft below ground surface and is either treated prior to drinking water use (currently the case at LAWC wells), or is not currently being extracted for use as drinking water (currently the case at the City of Pasadena Monk Hill Subarea wells). Therefore, at this time, there is no exposure pathway to groundwater at the JPL site. Because there is no complete pathway for exposure to untreated groundwater from beneath the JPL site, there is currently no human health risk associated with OU-3. However, if groundwater is not pumped and treated, VOCs and perchlorate may continue to migrate further within the Raymond Basin. Due to this possibility, Alternative 1 (NFA) is not protective of the groundwater and environment.

Under Alternative 2 (centralized treatment), protection of human health and the environment is achieved because the groundwater is treated prior to use as drinking water and chemicals do not migrate further. Alternative 2 does generate concentrated perchlorate and VOC waste in the form of spent ion exchange resin and carbon, respectively; however, this waste stream is easily managed and can be disposed of safely in accordance with state and federal requirements.

12.2 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs addresses whether a response action alternative meets all pertinent federal and state environmental statutes and requirements. An alternative must comply with ARARs or be covered by a waiver to be acceptable. This section discusses ARARs associated with RCRA, the South Coast Air Quality Management Board (SCAQMD), the Safe Drinking Water Act (SDWA), guidance set forth by the DHS, and local requirements of the City of Pasadena for construction and water use. In accordance with EPA guidance, only those requirements that are ARARs to the response action are discussed (EPA, 1999), see Table 12-1. Because the JPL site is on the NPL, the site is subject to the provisions of CERCLA as amended by Superfund Amendments and Reauthorization Act of 1986 (SARA).

An interim action must comply with action- and location-specific ARARs. However, an interim action does not need to comply with chemical-specific ARARs pertaining to aquifer restoration.

Chemical-specific ARARs associated with attaining aquifer cleanup will be addressed by the final remedy.

12.2.1 Chemical-Specific ARARs

Federal Safe Drinking Water Act and Federal MCLs. Treated water intended for drinking water use must comply with the federal ARARs associated with domestic use (federal MCL for PCE, TCE and CCl_4 in drinking water as promulgated by EPA under the Safe Drinking Water Act at 40 CFR § 141.61[a] and [c]). Therefore, the Safe Drinking Water Act is an ARAR for the treated effluent water from the LAWC and City of Pasadena treatment systems. Because this is an Interim ROD, establishing cleanup goals for the aquifer is not part of this response action. Cleanup goals for the aquifer will be addressed as part of the final remedy for groundwater.

California Safe Drinking Water Act and State MCLs. California has established standards that apply to sources of public drinking water, under the California Safe Drinking Water Act of 1976 (H&SC Section 4010.1 and 4026[c]) and State MCLs for organic chemicals set forth in California Code of Regulations (CCR), Title 22, Section 64444. Some State MCLs are more stringent than the corresponding federal MCLs, as is the case with CCl_4. In these instances, the more stringent State MCLs are applicable. NASA has determined that the substantive provisions of the standards in CCR Title 22, Section 64444 are relevant and appropriate because VOCs will be removed from drinking water to meet the requirements of the California Safe Drinking Water Act. Since this is an Interim ROD, establishing cleanup goals for the aquifer is not part of this response action. Cleanup goals for the aquifer will be addressed as part of the final remedy for groundwater.

California Public Health Goals. No federal or State MCL for perchlorate has been set. However, the California Health and Safety Code §116365(a) requires the DHS to set MCLs at a level as close as is technically and economically feasible to its PHG. The PHG is established by the California Office of Environmental Health Hazard Assessment (OEHHA) and is the concentration in drinking water that does not pose any significant risk to health derived from a human health risk assessment. OEHHA established a final PHG for perchlorate of 6 µg/L in March 2004 and, more recently, DHS has proposed to set the California MCL at 6 µg/L. On January 26, 2006, the EPA issued guidance that the recommended preliminary remediation goal for perchlorate be 24.5 µg/L. The preliminary remediation goal is not a drinking water standard, but it is a chemical-specific value to be considered by NASA. However, until a standard is established, the treatment plant would meet the State PHG, which is currently 6 µg/L. Once the final drinking water standard is established, all treatment plants will meet that level for perchlorate removal; until that time the PHG will be used.

RCRA Hazardous Waste Identification Criteria. These criteria are promulgated by the federal government to define RCRA hazardous waste. An RCRA hazardous waste is a waste that appears on one of the four hazardous wastes lists (F-list, K-list, P-list, or U-list), or exhibits at least one of four characteristics (of hazardous waste) − ignitability, corrosivity, reactivity, or toxicity. Hazardous waste is regulated under RCRA Subtitle C. This requirement may apply to the disposal of ion exchange and LGAC media. The spent media will be characterized in accordance with RCRA and will be disposed of accordingly.

Non-RCRA (California) Hazardous Waste Identification Criteria. These criteria are promulgated by the State of California to define non-RCRA (California) hazardous waste. A non-RCRA (California) hazardous waste can be identified as a listed waste, or as a waste that exhibits hazardous characteristics − ignitability, corrosivity, reactivity, and toxicity. This requirement may apply to the disposal of ion exchange and LGAC media. The spent media will be characterized in accordance with California hazardous waste requirements and will be disposed of accordingly.

12.2.2 Action-Specific ARARs

South Coast Air Quality Management District Rules. Fugitive dust must be controlled during construction to comply with SCAQMD Rules 401 and 403. No other SCAQMD rules apply since VOCs and perchlorate are removed prior to discharge into the Windsor Reservoir, which is a covered reservoir open to the atmosphere. In addition, the treatment system will be completely contained within piping and vessels, and no emissions will be associated with the system. Dust control measures will be taken during system construction so as to maintain compliance with the SCAQMD rules.

12.2.3 Location-Specific ARARs

There are no location-specific ARARs associated with the selected remedy under CERCLA. Because the Windsor Reservoir site is located within the city limits of Pasadena, as part of the new plant construction, the City of Pasadena will obtain local permits prior to constructing the new treatment facility. These include a Conditional Use Permit and a Building Permit. LAWC complied with the construction permitting requirements of the County of Los Angeles when it built its treatment plant in 2004.

In 1944, the Superior Court of California approved the Raymond Basin Judgment, which adjudicated the rights to groundwater production to preserve the safe yield of the groundwater basin.

Table 12-1. Summary of ARARs Relevant to the Selected Remedy for OU-3

Authority	Requirement	Status	Definition	Action Taken to Satisfy Requirement
Chemical-Specific ARARs				
Federal	Safe Drinking Water Act, Drinking Water MCLs – 40 CFR Part 141	Applicable	MCLs are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water.	All groundwater will be treated to meet the most stringent state and federal drinking water requirements.
State	California Safe Drinking Water Act of 1976, State MCLs – H&SC Section 4010.1 and 4026	Applicable	State MCLs are enforceable, regulatory standards under the California Safe Drinking Water Act and must be met by all public drinking water systems to which they apply.	All groundwater will be treated to meet the most stringent state and federal drinking water requirements.
State	California Public Health Goal for Perchlorate – H&SC Section 116293	To be considered (TBC)	Defines the level of a contaminant in drinking water below which there is no known or expected risk to health. PHGs are set by the California Environmental Protection Agency.	All groundwater will be treated to meet the permit conditions established by DHS.
Federal	Hazardous Waste Identification Criteria – 40 CFR 261	Applicable	Defines RCRA hazardous waste.	All spent media will be adequately characterized to determine if it qualifies as RCRA hazardous waste, and if so, spent media will be disposed of at a RCRA-permitted facility.
State	Hazardous Waste Identification Criteria – 22 CCR 66261.24	Applicable	Defines non-RCRA (California) hazardous waste.	All spent media will be adequately characterized to determine if it qualifies as non-RCRA (California) hazardous waste, and if so, spent media will be disposed of at a facility permitted to accept non-RCRA (California) hazardous waste.
Action-Specific ARARs				
State and Federal	SCAQMD Rules 401 and 402	Applicable	Fugitive dust must be controlled during construction to comply with SCAQMD criteria for acceptable dust levels.	Appropriate dust mitigation techniques will be employed during system construction.
Location-Specific ARARs				
There are no location-specific ARARs associated with the selected remedy.				

Adjudication refers to the practice of landowners and other parties allowing the courts to settle disputes over how much groundwater can rightfully be extracted. In an adjudicated groundwater basin, the court appoints a Watermaster to administer the court judgment and determine an equitable distribution of water that will be available for extraction each year. The Raymond Basin Management Board, made up of representatives of the water purveyors, oversees the management and protection of the Raymond Basin. A total of six Raymond Basin water purveyors, including the City of Pasadena and LAWC, operate wells in the Monk Hill Subarea. The City of Pasadena and LAWC will continue to be subject to the extraction, reporting, and monitoring requirements associated with the Raymond Basin Judgment.

In addition, CEQA requires that the City of Pasadena evaluate the selected remedy based on potential impacts to the following environmental factors: aesthetics, biological resources, hazards and hazardous materials, mineral resources, public services, utilities/service systems, agricultural resources, cultural resources, hydrology/water quality, noise, recreation, air quality, geology/soils, land use/planning, population/housing, and transportation/traffic. This process is currently ongoing and ensures that work is conducted in such a way that environmental impacts associated with the treatment plant are addressed.

12.2.4 Applicable Requirements and Guidance for Drinking Water

DHS guidance is applicable to the City of Pasadena and LAWC as part of purveying drinking water.

DHS Policy Memo 97-005. *Policy Memo 97-005: Policy Guidance for Direct Domestic Use of Extremely Impaired Sources* provides guidance by which DHS would evaluate proposals, establish appropriate permit conditions, and approve the use of a source for any direct potable use within a CERCLA operable unit (DHS, 1997). According to DHS policy, drinking water downgradient of the JPL facility is considered an "extremely impaired source" because it meets the following criteria as quoted in the policy: (1) a chemical exceeds three times its associated MCL or notification level based on acute health effects, and (2) the drinking water is considered threatened due to the proximity to known chemicals in the groundwater from the JPL facility. This policy requires additional documentation from the drinking water purveyor prior to restoring use of the drinking water supply wells. DHS Policy Memo 97-005 will be considered during implementation of the response action.

12.3 Cost-Effectiveness

Cost-effectiveness is determined by comparing the cost of all alternatives being considered with their overall effectiveness to determine whether costs are proportional to the effectiveness achieved. The overall effectiveness of a remedial alternative is determined by evaluating (1) long-term effectiveness and permanence, (2) reduction in toxicity, mobility, or volume through treatment, and (3) short-term effectiveness. Table 12-2 presents a comparison of costs and effectiveness of Alternative 1 (NFA) and Alternative 2 (centralized treatment) for OU-3.

Alternative 1 (NFA) is not effective over the long term because, under this alternative, VOCs and perchlorate can continue to migrate. Alternative 2 (centralized treatment) is effective over

the long term because the process permanently removes VOCs and perchlorate from the groundwater and future risks to off-facility groundwater are reduced. After remediation is complete, residual VOCs and perchlorate are not expected to further impact groundwater.

Alternative 1 (NFA) is not a treatment technology and does not reduce the toxicity, mobility, or volume of VOCs or perchlorate in the groundwater at OU-1. Alternative 2 permanently and irreversibly removes VOCs and perchlorate from groundwater. Therefore, only Alternative 2 reduces toxicity, mobility and volume of chemical concentrations in groundwater.

Alternative 1 (NFA) is not effective over the short term because no additional active remediation would be implemented to address chemical mass in groundwater and, as a result, chemicals in the groundwater can continue to migrate. Alternative 2 (centralized treatment) would be effective over the short-term. Risks to workers and the community during system construction and implementation would be controlled with good engineering practices and adherence to safe work practices. Centralized groundwater treatment would allow the immediate use of groundwater as a drinking water source. Ion exchange and LGAC have been implemented in the past (to treat perchlorate and VOCs, respectively) for drinking water purposes; therefore, each is an established technology that has gained acceptance from federal and state agencies. Ion exchange and LGAC are proven technologies with minimal startup issues and are able to supply clean water almost immediately upon installation, as demonstrated by the LAWC plant startup.

Table 12-2. Comparison of Costs and Effectiveness of Alternatives for OU-3

Alternative	Present-Worth Cost	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness
Alternative 1: NFA	$8,498,700	• Not effective in long-term • VOCs and perchlorate remain in groundwater and could migrate to off-facility areas	• No additional reduction in mobility or volume of VOCs or perchlorate	• Not effective in short-term • Drinking water usage of groundwater in the Monk Hill Subarea will not be restored • No construction; therefore, no short-term risks associated with worker and community safety
Alternative 2: Centralized Treatment	$68,397,000	• Effective in long-term • Permanent removal of perchlorate and VOCs from groundwater • Pumping provides long-term hydraulic control	• Reduces mobility and mass of VOCs and perchlorate through treatment • Provides hydraulic control to prevent migration	• Effective in the short-term • Allows for immediate use of groundwater in the Monk Hill Subarea by both the City of Pasadena and LAWC as a drinking water source • Risks to workers, community, and JPL employees would be protected with good engineering practice and adherence to safe work practices

The estimated present-worth cost of Alternative 1 (NFA) is $8,498,700. Alternative 1 does not reduce the toxicity, mobility, or volume of VOCs and perchlorate at OU-3, is not effective in the long term, and, therefore, is not a cost-effective alternative.

NASA and the regulatory authorities agree that the costs associated with centralized treatment (estimated present-worth cost of $68,397,000) are justified because the selected remedy will allow the immediate use of groundwater as a drinking water source for both LAWC and the City of Pasadena, while removing VOCs and perchlorate from off-facility groundwater and providing hydraulic control to prevent migration. Therefore, groundwater beneath JPL is protected, as required under both NCP (40 CFR Section 300.430(e)(2)(B)) and State of California regulations for the beneficial use of groundwater.

12.4 Use of Permanent Solutions and Alternative Treatment Technologies

Alternative 1 (NFA) cannot meet the remedial action objectives for OU-3 because, under this alternative, VOCs and perchlorate are left in place and unaffected groundwater is not protected. In addition, Alternative 1 is not a treatment technology, does not reduce the toxicity, mobility, or volume of chemicals of concern at OU-3, and is not effective over the long term, because VOCs and perchlorate are left in place with the potential to migrate.

Alternative 2 (centralized treatment) would permanently remove VOCs and perchlorate from the groundwater. Centralized treatment is effective over the long term, protective of human health and the environment, and meets all ARARs. Because Alternative 2 achieves all of the remedial action objectives and restores the beneficial uses of groundwater by the local community.

12.5 Preference for Treatment as a Principal Element

Alternative 1 (NFA) does not include treatment of groundwater. Alternative 2 (centralized treatment) includes treatment as a principal element which will remove VOCs and perchlorate from the groundwater, and provide hydraulic control to reduce chemical mobility. In addition, centralized treatment provides for immediate restoration of the OU-3 groundwater as a drinking water source. Therefore, Alternative 2 meets the CERCLA preference for treatment as a principal element.

12.6 Five-Year Review Requirements

NASA intends, to the extent practicable, to remove VOCs and perchlorate in the groundwater at JPL and prevent further migration of VOCs and perchlorate to unaffected groundwater used for drinking water. A review will be conducted every five years to ensure that the remedy continues to provide adequate protection of human health and the environment.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. *Public Health for Jet Propulsion Laboratory.* U.S. Department of Health and Human Services.

California Department of Health Services (DHS). 1997. *Policy Memo 97-005: Policy Guidance for Direct Domestic Use of Extremely Impaired Sources*. November 5.

Ebasco. 1988. *Preliminary Assessment/ Site Inspection Report for Jet Propulsion Laboratory, Pasadena, California*. April.

Ebasco. 1990a. *Expanded Site Inspection Report for NASA-Jet Propulsion Laboratory, Pasadena, California*. May.

Ebasco. 1990b. *Supplemental Information to the Expanded Site Inspection Report for NASA-Jet Propulsion Laboratory, Pasadena, California*. November.

Foster Wheeler Environmental Corporation (FWEC). 1999. *Final Remedial Investigation Report for Operable Units 1 and 3: On-Site and Off-Site Groundwater*. National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, CA. August.

Foster Wheeler Environmental Corporation (FWEC). 2000. *Final Feasibility Study Report for Operable Unit 2: Potential On-Site Contaminant Source Areas*. National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, CA. July.

Foster Wheeler Environmental Corporation (FWEC). 2000. *Draft Feasibility Study Report for Operable Units 1 and 3: On-Site and Off-Site Groundwater*. National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, CA. January.

National Aeronautics and Space Administration (NASA). 2002. *Final Record of Decision and Remedial Action Plan for Operable Unit 2, National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California*. September.

National Aeronautics and Space Administration (NASA). 2003a. *Revised Final Operable Unit 1 Expanded Treatability Study Work Plan*. NASA Jet Propulsion Laboratory. NAS7.010106, NASA-JPL, SSIC No. 9661. October.

National Aeronautics and Space Administration (NASA). 2003b. *JPL Groundwater Modeling Report*. NASA Jet Propulsion Laboratory. December.

National Aeronautics and Space Administration (NASA). 2004. *Action Memorandum For the Lincoln Avenue Water Company (LAWC), Altadena, California Associated with Groundwater Cleanup at the National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, California*. August.

National Aeronautics and Space Administration (NASA). 2006a. *National Aeronautics and Space Administration Environmental Cleanup Program Community Involvement Plan (Second Update) for the CERCLA Site at the Jet Propulsion Laboratory*. August.

National Aeronautics and Space Administration (NASA). 2006b. *Final Proposed Plan to Fund Construction and Operation of Treatment Systems for Groundwater from Drinking Water Wells*. NASA Jet Propulsion Laboratory. April 19.

National Aeronautics and Space Administration (NASA). 2006c. *Technical Memorandum Alternatives Evaluation for the City of Pasadena Treatment Plant*. NASA Jet Propulsion Laboratory. June 16.

National Aeronautics and Space Administration (NASA). 2006d. *National Environmental Policy Act of 1969 (NEPA) Values Assessment for the National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California.* November.

National Aeronautics and Space Administration (NASA). 2006e. *Perchlorate Treatment Technologies Literature Review.* NASA Jet Propulsion Laboratory. June.

National Aeronautics and Space Administration (NASA). 2006f. *Final Interim Record of Decision for the Operable Unit 1 Source Area Groundwater.* NASA Jet Propulsion Laboratory. November.

Pasadena, City of. 2006a. *Request for Proposals: Design and Installation of Ion Exchange and Liquid Granular Activated Carbon Treatment Systems for Removal of Perchlorate and Volatile Organic Compounds from the Monk Hill Wells*. Pasadena Water and Power.

Pasadena, City of. 2006b. "The Arroyo Seco in Pasadena". Available at: http://www.ci.pasadena.ca.us/ publicworks/PNR/ArroyoSeco/.

United States Environmental Protection Agency (EPA). 1989. *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual (Part A).* Interim Final. Office of Emergency and Remedial Response, EPA/5401/1-89/002. December.

United States Environmental Protection Agency (EPA). 1990. *40 CFR Part 300: National Oil and Hazardous Substances Pollution Contingency Plan*.

United States Environmental Protection Agency (EPA). 1996. *Presumptive Response Strategy and Ex Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites.* Office of Solid Waste and Emergency Response. EPA 540/R-96/023. October.

United States Environmental Protection Agency (EPA). 1999. *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents.* Office of Solid Waste and Emergency Response. EPA 540/R-98/031. July.

Part III: THE RESPONSIVENESS SUMMARY

The purpose of the Responsiveness Summary is to provide an opportunity for the National Aeronautics and Space Administration (NASA) to review and respond to the public's comments, concerns, and questions about the location and the remedial technology selected to clean up off-facility groundwater at the Jet Propulsion Laboratory (JPL).

1.0: OVERVIEW

After a thorough analysis of the comments received, NASA has decided to proceed with the preferred alternative described earlier in this Interim Record of Decision (ROD), which includes:

(i) Funding the construction and operation of a new centralized groundwater treatment plant for the City of Pasadena (City) production wells located within the Monk Hill Subarea. The system will be located at the City of Pasadena's Windsor Reservoir site, pending approval and permitting by the City. NASA will provide funding to the City to design and construct the plant. The City will be responsible for operation and maintenance of the system with NASA funding.

(ii) Continuing to fund a centralized groundwater treatment plant operated by Lincoln Avenue Water Company (LAWC).

(iii) Continuing to perform groundwater monitoring.

This response action is part of a comprehensive approach to reduce concentrations of target chemicals in groundwater to meet drinking water requirements, thus restoring the natural groundwater resource underneath and adjacent to the JPL facility. Centralized treatment also allows for the immediate use of groundwater as a drinking water source, thereby restoring the beneficial use of the aquifer.

2.0: BACKGROUND ON COMMUNITY INVOLVEMENT

Initial interviews with community members and leaders in 1991 and again in 1993 indicated a relatively low level of awareness in the three surrounding communities of La Cañada, Altadena, and Pasadena regarding the placement of JPL on the National Priorities List. During these interviews, residents suggested using community newsletters to convey important information in addition to the media exposure NASA was already using (NASA, 2006). Since then, NASA has addressed these concerns through community newsletters and fact sheets, which have been distributed to members of the surrounding communities, and through numerous other actions.

Additional interviews of local residents, community leaders, and JPL employees in January 2005 showed a much greater level of awareness about the groundwater cleanup program, with residents commenting on their appreciation of NASA's efforts to communicate with the public (NASA, 2006).

In May and June 2001, three public meetings were held to inform the public of the remediation alternatives chosen as part of the Proposed Plan for OU-2 to clean up on-facility soils at JPL. A Public Comment Period gave the public an opportunity to ask questions and state their concerns about on-facility soil treatment. Comments submitted during the public comment period were collected and reviewed including comments on community involvement opportunities and needs.

In January 2004, NASA held two public meetings and a meeting for JPL employees to solicit community input regarding the groundwater cleanup process and to update the community on NASA's groundwater cleanup efforts. In April 2004, a Community Meeting on Health was held. A panel of medical and public health experts gathered, along with NASA Project and Community Outreach Managers, to address questions from the public about the possible health effects of perchlorate and volatile organic compounds (VOCs) (NASA, 2004).

In March 2005, NASA hosted a Community Information Session. Local residents met with members of NASA's Groundwater Cleanup Project team, local water purveyors, and health and technical experts to learn about NASA's progress in cleaning up groundwater beneath JPL and areas adjacent to it.

On November 16, 2005, NASA held a Public Meeting on the Proposed Plan for OU-1, on-facility clean up of groundwater. Public notification of the Proposed Plan and public meeting was mailed to approximately 17,000 residents of the surrounding communities, and e-mailed to approximately 5,000 JPL employees. Public notification of the meeting on November 16 was also provided in local newspaper display ads. The meeting was held to present the Proposed Plan to the public, and the public comment period was open from November 1 through December 15, 2005. During this time, members of the public had the opportunity to comment on and ask questions about the information presented in the public meetings and in the Proposed Plan.

On April 19, 2006, NASA issued the *Proposed Plan to Fund Construction and Operation of Treatment Systems for Groundwater from Drinking Water Wells* which presented the Preferred

Alternative for implementing a cleanup for off-facility groundwater. NASA mailed a newsletter describing the OU-3 Proposed Plan to area residents on April 14, 2006. A small meeting for residents living within 500 feet of the proposed Windsor Avenue location was held on April 5, 2006, at Five Acres School in Pasadena, adjacent to the Windsor Reservoir site. These residents closest to Windsor Reservoir were provided information about the meeting via the U.S. Mail, and/or letters hand-delivered to their residences.

A public meeting was held on May 3, 2006, to address the OU-3 Proposed Plan and to allow the public to comment or ask questions about the Preferred Alternative. Based on requests from the public received during the public meeting, NASA extended the public comment period from May 19 to July 7, 2006, and also issued a Technical Memorandum that evaluated potential locations of the new City treatment plant. This evaluation was intended to further document NASA's evaluation of potential locations, and present the public with additional information relating to the selection of the Windsor Reservoir as the preferred location. The Technical Memorandum was presented publicly at another public meeting on June 21, 2006, and residents were given the opportunity to ask questions and provide comments. Residents were informed of the two public meetings and the public comment period through newspaper ads, flyers in the community, and by a postcard mailing to over 17,000 local residents on NASA's mailing list.

NASA continues to regularly update its Web site (http://jplwater.nasa.gov) with news and information about the cleanup program. Official documents related to the cleanup can be found in the Administrative Record section of this Web site, or at the four Information Repositories:

La Cañada Flintridge Public Library
4545 Oakwood Avenue
La Cañada Flintridge, CA 91011
(818) 790-3330

Pasadena Central Library
285 E. Walnut Street
Pasadena, CA 91101
(626) 744-4052

Altadena Public Library
600 E. Mariposa Avenue
Altadena, CA 91001
(626) 798-0833

JPL Library
(JPL Employees Only)
4800 Oak Grove Drive
Bldg. 111-112
Pasadena, CA 91109
(818) 354-4200

3.0: SUMMARY OF PUBLIC COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND RESPONSES FROM NASA

This section summarizes key issues expressed by the public during the public comment period (April 19, 2006 to July 7, 2006) and the responses from NASA regarding these issues. The meeting transcript from the May 3 Public Meeting is available in the information repositories and Appendix B contains copies of each of the letters and comment cards that were submitted during the public comment period. Sections 3.1 through 3.8 provide the categories of the questions and comments received that were shared by three or more members of the community and Section 3.9 addresses comments that were expressed by only one or two individuals in the community.

NASA received comments on the Proposed Plan from a total of 31 people, several of whom had comments on multiple aspects of the Proposed Plan. There were nine commenters who sent in comment cards provided at the various public meetings. Another four commenters sent their comments by letter via the U.S. Mail. A remaining nine commenters provided comments via e-mail directly to NASA. This summary also includes verbal comments made on the record during the May 3 Public Meeting, only nine of which did not also submit written comments.

3.1 Clarification/Description of the Monk Hill Treatment System

Eight comments were received by NASA concerning various aspects of the proposed City of Pasadena Treatment System in the Monk Hill Subarea. These comments addressed operational issues such as how the plant cleans the water, what happens to the water once it has been cleaned (i.e., whether it will be used for drinking water), plant maintenance, the operation schedule of the proposed plant, effectiveness of the system, and the costs associated with constructing and operating the facility.

NASA Response:

The treatment system will consist of ion exchange to remove perchlorate and liquid-phase granular activated carbon to remove VOCs. The system will be designed to extract groundwater from four production wells owned by the City of Pasadena and located within the Monk Hill Subarea. Pending the City's permitting process; the system will be located at the Windsor Reservoir site. NASA will conduct the initial site preparation and construction activities for the City. The City will be responsible for system start-up and ongoing operation and maintenance of the facility with funding from NASA. The extracted groundwater will be treated to meet applicable federal and state drinking water standards set by the U.S. Environmental Protection Agency (EPA) and the State of California. The extracted groundwater will then be piped to the Windsor Reservoir where, pending testing and California Department of Health Services approval, it will be available for use as part of the City's water supply. There will be no reinjection of groundwater at the Windsor Reservoir site.

The treatment system will be designed to have no air emissions, and groundwater pumped from the production wells will be completely contained within pipes and vessels to reduce the potential for exposure during any part of the treatment process. These enclosed vessels contain filters that take chemicals out of the groundwater. Over time, chemicals build up on the filter

material and the filter will be exchanged with a new filter by a qualified waste management vendor. The used filter will be taken away in a contained form as waste. The system is designed such that throughout the life-cycle of the treatment process, the filters are not exposed to the atmosphere at any point. Filters will be replaced once or twice a month and the used filter material will be taken offsite to a licensed hazardous waste facility and disposed of according to state and federal waste disposal requirements.

The treatment system will operate as necessary to meet the water demands of the City. Current estimates have indicated that the system will likely operate for approximately five to seven months out of the year. Operation will likely occur during the warmer months when water demand is the highest. Water demands often fluctuate from year to year, therefore, if necessary, the City may operate the system longer to meet their water demands.

Regarding treatment system costs, preliminary cost estimates indicate that the Monk Hill treatment system will cost approximately $3.2 million dollars to build, and approximately $3.1 million dollars a year to operate, with funding provided by NASA.

3.2 Evaluation of other Locations and Selection of the Windsor Reservoir Site

NASA received 17 comments from the public about the selection of the Windsor Reservoir site and the evaluation of other locations, including the JPL site, for the proposed treatment plant. Concerns included requests for further information about the basis for selecting the Windsor Reservoir site, questions about the evaluation of other potential locations for the proposed treatment plant, including the assertion that independent experts be a part of that evaluation process, and comments that NASA should consider additional locations, particularly the JPL site. A few commenters also asked if cost was the reason for selecting the Windsor Reservoir site, and another commenter asked whether JPL's parking situation affected the selection process.

NASA Response:

Many of these comments were received by NASA early in the process (i.e., at the initial May 3 Public Meeting). In light of this, NASA provided more detailed information on the factors examined during its evaluation process in the form of a Technical Memorandum dated June 16, 2006. The intent of the Technical Memorandum was to document the various locations NASA considered for the centralized treatment plant; to present the criteria that NASA systematically applied to each location; and to allow the public to evaluate the basis for NASA's selection of the Windsor Reservoir as the preferred location for the Monk Hill Treatment System. The Technical Memorandum provided an analysis and evaluation of the viability of other potential locations besides the Windsor Reservoir, reviewing a total of six potential site locations, including two JPL locations. Following the release of the Technical Memorandum, NASA held a meeting on June 21, 2006 to discuss the evaluation of these alternative locations, including one additional location (the Sheldon Reservoir) that was added and evaluated based on community comments from the May 3 meeting.

The six locations evaluated were the Behner Surface Water Treatment Facility, the JPL East Parking Lot, the Windsor Reservoir site, the location of the Existing Air Stripping Facility, the JPL South Parking Lot, and the Sheldon Reservoir. The Technical Memorandum dated June 16, 2006, evaluated each site based on the nine criteria for evaluating alternatives required by the National Oil and Hazardous Substances Contingency Plan. The nine criteria are categorized into three groups:

Threshold Criteria (an alternative must meet these otherwise it cannot be selected)

1. Overall Protection of Human Health and the Environment
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) − This criterion is used to evaluate the potential for the alternative to comply with ARARs, which are the federal, state and local laws and regulations applicable to the alternative.

Primary Balancing Criteria (these are used to identify the best alternative among those that meet the threshold criteria)

3. Long-Term Effectiveness and Permanence − This criterion is used to evaluate the ability of the alternative to protect human health and the environment after the remedial action is completed.
4. Reduction of Toxicity, Mobility, or Volume of Contaminants − This criterion is used to evaluate the ability of the alternative to eliminate or significantly reduce the toxicity, mobility, or volume of contaminants.
5. Short-Term Effectiveness − This criterion is used to evaluate the protectiveness to human health and the environment during the construction and implementation of the alternative.
6. Implementability − This criterion is used to evaluate the technical feasibility, administrative feasibility, and availability of services and materials.
7. Cost − Cost considerations include capital costs and present value costs. Capital costs are the costs associated with the implementation of the alternative. These include direct costs (equipment, labor, and materials for implementation of the cleanup alternative) and indirect costs (engineering and other costs not directly associated with construction). Present value costs, the costs in currently valued dollars of the money to be expended over a period of time, are used for comparative analysis.

Modifying Criteria (state and community acceptance may modify the Preferred Alternative identified through the evaluation of the Primary Balancing Criteria).

8. State Acceptance − This criterion is used to address technical and administrative concerns that the agencies may raise during the review process.
9. Community Acceptance − This criterion is used to evaluate the concerns that the public may have and the anticipated level of acceptance by the public.

Based on the evaluation, the Windsor Reservoir site is considered the preferred location, as it offers the best balance of long-term effectiveness, short-term effectiveness, implementability, and cost (see Section 9.3 of Part II of this Interim ROD).

Note that cost is only one of the criteria considered. Cost is a Primary Balancing Criterion, which is considered secondary to the protection of human health and the environment, which must be satisfied before an alternative can even be considered.

Two of the six locations evaluated for the centralized treatment system were on JPL parking lots. Although these locations were considered potentially feasible, they had significant implementability issues (e.g., construction and piping across the Arroyo Seco). As to whether NASA's decision was impacted by JPL's parking situation, NASA does not consider the loss of a few dozen parking spaces an implementability issue. The potential loss of parking did not impact NASA's decision on the preferred location.

The primary purpose of the treatment plant is to restore drinking water wells by removing chemicals that are in the groundwater; therefore, NASA selected the treatment technology, and identified the preferred location that would most safely and effectively meet that goal.

3.3 Concerns about Visual Impact

NASA received 15 comments addressing public concerns about the treatment system being built in the residential setting of the Windsor Reservoir, and expressed strong concern for visual impact of the proposed plant, including system size, design and landscaping. Additionally, approximately 20 community members verbally noted their disagreements about the selection of the site location, citing concerns about the City of Pasadena's historic neglect about the condition of the site.

NASA Response:

NASA recognizes the concern by community members about the potential visual effects of the treatment plant at the Windsor Reservoir given the residential setting and the proximity to residences. To respond to this concern, NASA will fund and provide support to the City for reducing noise (such as acoustical materials to decrease sound) and improving aesthetics (including landscaping). In addition, the City's Request for Proposals for potential vendors includes explicit criteria that look at the vendor's ability to reduce impacts to the surrounding community to enable the treatment facility to better blend into the residential area surrounding the site.

It is anticipated that the treatment system will consist of 15 to 25 vessels. The exact setup of these tanks will be determined once a vendor has been selected by the City. These tanks will be designed to withstand extreme conditions, including seismic forces and inclement weather. The system will also include sensors and valves that will shut down the system in the event of a potential problem.

In response to community concerns about aesthetics, NASA hired a team of landscape architects to develop landscaping options for the City toward improving the overall look and curbside appeal of the Windsor Reservoir site. These efforts will involve developing a conceptual plan for the appearance of the site, including specific proposals for a variety of plants and shrubs, designs, and drawings of how various landscaping approaches might appear from Windsor

Avenue and the surrounding neighborhood. These plans may, among other things, include a winding walkway, newly planted shrubs, and additional trees along the Windsor Avenue frontage. The City has stated its intention to discuss the landscape plan with residents, and receive resident input on their preferences and plant selections prior to proceeding with landscaping.

In addition to the plans for external landscaping improvements, the City has issued a Request for Proposal (RFP), inviting potential vendors to submit bids for the service of designing and building the groundwater treatment system. In this RFP, the City specifically listed aesthetics as an important factor in the design and evaluation/vendor selection process. During a walk-through of the site by the vendors (in which NASA representatives also attended), City officials emphasized the importance that aesthetics would play in selecting a vendor.

3.4 Environmental, Safety and Health Concerns

NASA received 18 comments that addressed environmental and health concerns associated with the treatment plant being located at the Windsor Reservoir. People expressed concerns about the Windsor Reservoir being in a residential setting as well as near a school, and they wanted to know what the impacts might be on the local community. Their comments included concerns about potential health effects of the chemicals being treated at the site, as well as potential environmental effects that might be associated with the plant, including questions about leakage and potential pollution associated with the treatment of the chemicals at the site, in the event of an earthquake, or even during normal operation.

NASA Response:

NASA acknowledges concerns regarding the Windsor Reservoir being in a residential area. This property has been used for water supply purposes for over a century. The City has used the property for water storage and distribution since 1912. NASA is working with the City to build a system with safety as a priority. The treatment system will be a closed system, which means that all of the tanks and system components are closed. The groundwater that is extracted and treated is fully contained in these closed tanks to prevent exposure to area residents or the environment. In addition to the groundwater treatment components, the City will also need to use chemicals to disinfect the water prior to distribution for potable use. Disinfection is a required part of all municipal drinking water treatment systems. This disinfection process happens after the chemicals are removed and before the water reaches Pasadena's distribution system. The selected vendor's design will contain specifics as to how these chemicals will be safely used and secured. The disinfection technique proposed by the City for use includes modifying the existing gas chlorine system at the Windsor Reservoir and introducing ammonium hydroxide (liquid ammonia) to produce chloramines. In accordance with State requirements, these chemicals must be managed by qualified City personnel. The ammonium hydroxide will be stored in a 2,000 gallon tank (approximate) and chlorine gas will be delivered to the site and stored in steel cylinders. Both chemicals will be located on a concrete pad, and the ammonium hydroxide tank will be surrounded with a concrete berm to contain any potential spills. A secure, enclosed structure will fully contain the chemicals (per Pasadena Fire Department requirements) to contain any vapors produced in case of any potential spills and leaks.

The treatment system will include many factors to ensure stability during periods of seismic activity and inclement weather. The structural components (i.e., piping and vessels) of the system will be designed to sustain forces resulting from seismic activity and inclement weather. In addition, sensors will be incorporated into the system design. These sensors will be used to transmit pertinent operational information during system operation. The sensor network will be programmed so that the system can automatically shut down in the event of any potential problems. In addition, valves will be installed throughout the system. These valves can be opened or closed and thus can allow or prevent water from flowing. A number of other safety mechanisms will be incorporated into the system design.

The City is also required by the California Environmental Quality Act (CEQA) to evaluate the Windsor Reservoir regarding potential impacts to the following environmental factors: aesthetics, biological resources, hazards and hazardous materials, mineral resources, public services, utilities/service systems, agricultural resources, cultural resources, hydrology/water quality, noise, recreation, air quality, geology/soils, land use/planning, population/housing, and transportation/traffic. The City's CEQA process ensures that work is conducted in such a way that environmental impacts associated with the treatment plant are minimized. The City's CEQA process is currently underway and the environmental assessment will be available for public review as part of the City's approval process.

As stated above, the treatment system will be completely contained, thus protecting against exposure. As the groundwater is treated, the chemicals that are removed get absorbed and will build up in the treatment units; this is by design. These filters will be exchanged with new filter media by a qualified waste management vendor, and the used filter media will be taken away as contained waste. The used filter media will be transferred from the treatment vessels to a tanker truck via large hoses. The new filter media will be transferred via a similar process from the tanker truck to the treatment vessels. The vendor will be chosen in part based on previous experience and safety record and will be qualified to handle the waste generated by the treatment facility.

Some commenters raised concerns about potential risks associated with exposure to groundwater. The Agency for Toxic Substances and Disease Registry (ATSDR) conducted site visits in 1997 to assess the potential for public health hazards associated with the groundwater adjacent to the JPL facility. ATSDR determined that the VOCs in groundwater do not present a past, present, or future public health concern to JPL employees or nearby residents. On-facility groundwater has never been used as a source of drinking water and area water purveyors regularly monitor to ensure that water meets the federal and state water quality goals. Based on an analysis performed by the ATSDR, it was determined unlikely that perchlorate in groundwater posed a past public health hazard.

Because of the closed system design, at no point is the water exposed to the outside environment. The water to be treated is pumped up from the ground, sent through the treatment system for treatment and disinfection, and then the clean water is stored in the Windsor Reservoir for distribution through the residential/commercial drinking water network. Though extremely unlikely, even if a worker were to have limited dermal contact with untreated water, it

would not pose a health concern. The potential for health risks would only be possible if untreated water was used for drinking water over a lifetime. The proposed treatment plant will remove the chemicals to provide acceptable for drinking water.

3.5 Potential Impacts of Construction and Operation of Plant on the Community

NASA received 21 comments regarding concerns about the impact on the residents living near the Windsor Reservoir site from both the construction and operation of the proposed groundwater treatment system. They included various concerns about the construction including noise, dust, and concerns about traffic on Windsor Avenue, and the duration of construction. Some concerns were also expressed about noise and traffic during the operation of the plant.

NASA Response:

NASA recognizes that residents have concerns about construction and operation of the plant and that residents want to maintain the existing residential character of the area. Both NASA and the City have stated their intent to make sure the facility is well-maintained.

Initial construction and site preparation will be carried out by NASA and its contractors in order to support the City. NASA will make every effort to minimize construction-related impacts during this process. Final construction, landscaping, and operation of the plant will be carried out by the City.

Measures will be taken to minimize the amount of dust generated at the Windsor Reservoir location during system construction, including watering dusty areas at the site and covering any excavated material with plastic sheeting.

The City is required by the Departments of Public Works and Transportation to prepare a traffic management plan as part of the project planning phase. The City's traffic management plan must include an evaluation of trucking routes. Mitigation measure may include signage, a traffic monitor, and potential alterations to the roadway near the access to the site. Project-related vehicles would use Windsor Avenue during construction. Assuming that the project is not interrupted, it is expected to take approximately three to four months to construct the treatment system at the Windsor Reservoir location.

At this time, the City estimates that the large tanker trucks will be present onsite once or twice a month after the construction period to service the treatment system. After initial construction, the City, with funding support from NASA, will be responsible for operating the system and maintaining the facility.

The design of the Monk Hill treatment facility is still in preliminary stages; however, the City has issued a RFP and is reviewing vendor proposals. The City has indicated they will include visual and noise impacts among its selection factors. NASA is working with the City to help ensure that noise levels will be a priority design consideration during the planning stages of the project. Accordingly, NASA will fund implementation of acoustical controls designed to

mitigate and minimize noise resulting from the system and thus reduce impacts to the community. Acoustical controls usually consist of using materials that absorb sound waves to minimize the noise (i.e., acoustical materials may be used to enclose sound generating components of the system). At a minimum, the Monk Hill treatment system must comply with noise standards required by the City. For a residential area, such as the Windsor Reservoir site, operational noise levels will comply with the relevant requirement, which are 45 dB between 10 p.m. and 7 a.m. and 50 dB between 7 a.m. and 10 p.m. These noise levels are comparable to background noise heard in an urban setting.

NASA has emphasized to the City that operating and maintaining the property in keeping with the character of the surrounding neighborhoods is a core value for NASA funded cleanup activities. To this end, NASA has hired professional landscape architects to work on the preliminary site planning ideas that will add to the curb appeal on Windsor Avenue. Some possibilities being discussed include sitting the facility behind fencing of a pleasing design, using appropriate materials and color, planting shrubs and trees, and selecting an appropriate design for security lighting.

The City issued a RFP, inviting vendors to submit bids for the service of designing and building the groundwater treatment system. In this RFP, the City made specific mention of aesthetics being an important factor in the design and evaluation/vendor selection process. During a walk-through of the site by the vendors and NASA representatives in September 2006, City officials emphasized the importance that aesthetics would play in its final determination of a vendor.

3.6 Concerns about Property Values

Several community members expressed concerns about the property values of the homes in the immediate vicinity of the Windsor Reservoir, including a question about whether or not someone would need to disclose information about water issues when selling a house.

NASA Response:

The Windsor Reservoir has been owned by the City of Pasadena and used for various purposes since they took ownership of the property in 1912, before homes were built in the immediate area. The use of this property for water treatment purposes is consistent with past use and existing zoning, thus no change to real estate disclosure practice is anticipated.

As stated above in Section 3.5, NASA has emphasized to the City that operating and maintaining the property in keeping with the character of the surrounding neighborhood is a core value for NASA funded projects.

3.7 Potential for Additional Treatment

Three commenters expressed concerns by the public that future treatment plants may need to be constructed to clean up the chemicals, in the event that information is revealed that the plume has moved farther than previously thought.

NASA Response:

NASA is taking a comprehensive approach to the cleanup that includes treatment systems both on and off the JPL facility. The LAWC and the City of Pasadena treatment systems are a part of an overall remedy NASA is funding and implementing to clean up the target chemicals in groundwater beneath and adjacent to JPL. The operation of the Monk Hill treatment system at the Windsor Reservoir will add an additional level of hydraulic control to prevent further migration of the chemicals in groundwater. Based on groundwater modeling and monitoring data, it is expected that the three systems will together effectively contain the plume, and over time reduce concentrations so that the groundwater meets state and federal standards.

The U.S. EPA, the State of California, and NASA are committed to continuing this cleanup project until it reaches completion. Additionally, all of NASA's cleanup activities are undertaken according to CERCLA regulations, and are regulated by the U.S. EPA, California Department of Health Services, and the California Regional Water Quality Control Board. Based on groundwater modeling, NASA currently estimates that it will take approximately 18 years to clean up the off-facility groundwater to levels that meet the water quality standards required by the State of California and the U.S. EPA.

If further treatment systems are needed in the future, NASA will follow CERCLA regulations, which include requirements for community involvement.

3.8 Public Notification and Public Involvement

NASA received 12 comments relating to public notification and public involvement. The community expressed a strong desire to be involved in the public process and decision-making with regard to the Proposed Plan. Some residents expressed concern that there may not be sufficient opportunities to be involved in this process. A few members of the community expressed concern that they were not being notified of public meetings or receiving updates about NASA's groundwater cleanup program at JPL.

NASA Response:

NASA recognizes the importance of working closely with the public and has significantly increased its outreach over the past few years to provide many opportunities to both update the public and receive their input. Outreach activities have included multiple public meetings and information sessions, the distribution of newsletters and other information, providing a regularly updated project Web site, and holding community interviews. NASA has made efforts to expand its outreach to multicultural groups through the issuance of bilingual newsletters and including various groups in the community interviews designed to determine information needs, concerns and preferences for information and involvement.

The community involvement process required by CERCLA includes providing an opportunity for the community to comment before a decision is made regarding the selection of a remedial response action. This process includes preparing an Administrative Record, making it available, and having at least a 30-day public comment period after the issuance of a Proposed Plan and

any public meetings. The Administrative Record is the collection of documents that forms the basis for selecting a CERCLA response action, and NASA considered or relied upon documents in this record in selecting the proposed OU-3 remedial response action. More details about this process can be found at 40 CFR 300.800 through 300.825.

NASA distributes periodic newsletters in order to raise general public awareness about the groundwater cleanup program at JPL. For each publication, NASA distributes over 17,000 newsletters to local residents on its mailing list which consists of local residents residing in the immediate vicinity of JPL, as well as members of the community who have signed up to receive information on various public meetings and events. The newsletter serves to raise general public awareness about the groundwater cleanup program at JPL. For every public meeting, NASA notifies the public in a number of ways, including through the aforementioned bilingual newsletter, flyers, postcards, and announcements/ads published in local newspapers. NASA has placed announcements in the *Pasadena Star-News*, the *Pasadena Weekly*, the *Pasadena/San Gabriel Valley Journal*, the *La Cañada Valley Sun*, and the *La Cañada Flintridge Outlook*. NASA also maintains a Web site that details activities associated with the cleanup.

NASA held three community meetings to discuss different aspects of the OU-3 Proposed Plan. The first meeting was held April 5, 2006, for residents living nearest to the Windsor Reservoir site. Residents were notified of the meeting through a letter from NASA, either hand-delivered or via the U.S. Mail. The meeting provided neighbors closest to the site a chance to ask questions and learn more about the Proposed Plan. The Proposed Plan was issued on April 19, 2006.

The second meeting was held on May 3, 2006. The public was made aware of this meeting, along with other information about the groundwater cleanup program, in the May 2006 Bilingual Newsletter. NASA placed advertisements in the *Pasadena Weekly, Pasadena Star-News*, and the *Pasadena/San Gabriel Valley Journal News* to announce the meeting and provide information about the Proposed Plan. Finally, flyers were distributed at Pasadena and Altadena community and senior centers, as well as local libraries, including the Altadena Public Library, the La Cañada Flintridge Public Library, and the Pasadena Central Library. Attendees at the May 3 meeting were given the opportunity to ask questions of NASA project managers, both formally and informally, and to make formal comments on the record. The official Public Comment Period for the Proposed Plan began on April 19, 2006, and was originally planned to end 30 days later on May 19, 2006. In light of community interest, however, NASA extended the public comment period by seven weeks, making the ending date July 7, 2006. The extension of the public comment period was published in the *Pasadena Weekly* and the *Pasadena/San Gabriel Valley Journal News.*

A third public meeting was held on June 21, 2006. Again, NASA placed advertisements in local newspapers, and flyers were delivered to area libraries and community and senior centers. The community was also informed of this meeting through a bilingual postcard mailing that was sent out to the mailing list of over 17,000. Since the public meetings for this proposal, NASA updated its mailing list and contacted local post offices and the original mail list service company to make every effort to include all residences in the area.

NASA also routinely updates its Web site (http://jplwater.nasa.gov) with the most current information about the groundwater cleanup program. This includes online access to the Administrative Record files, which can also be found at the local information repositories that include the Altadena Public Library, the La Cañada Flintridge Public Library, and the Pasadena Central Library. NASA remains committed to promoting community awareness about this project and providing meaningful opportunities for the public to give input. For more information about community involvement or other issues related to NASA's Groundwater Cleanup Program at JPL, NASA has a dedicated Manager for Community Involvement, Merrilee Fellows, who is available at 818-393-0754 or via e-mail at mfellows@nasa.gov.

In addition to the opportunities for community members to make official comments during NASA's public comment period, there are other opportunities to participate in the processes that the City must go through, including CEQA and permitting processes, before getting approval to construct the plant at the Windsor Reservoir site. This also includes opportunities to comment during design review by the City of Pasadena and during the California Department of Health Services approval process.

3.9 Lincoln Avenue Water Company's Involvement

There were a few comments about LAWC and its involvement and participation in the cleanup effort. One individual questioned LAWC's continued involvement in the groundwater cleanup at OU-3, and asserted that LAWC should cease that involvement. Two other individuals felt that LAWC did not have enough involvement in the process and desired to see-the water company more involved. A fourth individual wondered whether LAWC might not be treated the same as the City of Pasadena and asserted that Lincoln Avenue should also receive enhancements to the physical appearance of the LAWC water treatment plant.

NASA Response:

NASA has funded treatment at LAWC since the early 1990s, beginning with the installation and operation of a VOC treatment facility at the LAWC property. NASA is currently funding, and has proposed to continue to fund, the LAWC to operate a treatment facility that treats VOCs and perchlorate in groundwater. This system has been operating successfully since July 2004. NASA's Proposed Plan includes treatment activities regarding both the City of Pasadena and the LAWC in the Monk Hill Subarea, thus one component of the Proposed Plan would continue funding the operation of the treatment facility for LAWC. LAWC attends public meetings because NASA funds, and will continue to fund, the treatment facility for LAWC. NASA works closely with LAWC regarding how that treatment facility fits into the neighborhood and NASA recently has funded some aesthetic enhancements for the LAWC plant.

3.10 Miscellaneous Comments

The following subsections present questions and comments that were expressed by only one or two individuals on each subject.

3.10.1 Evaluation of Extraction, Treatment and Reinjection

NASA received a comment questioning why extraction, treatment, and reinjection was not evaluated in the proposed plan as an alternative for cleaning up OU-3 groundwater. Another commenter stated that multiple alternatives must be presented.

NASA Response:

NASA did acknowledge the potential for on-facility extraction, treatment and reinjection in the Proposed Plan. A detailed evaluation was also included in the Technical Memorandum dated June 16, 2006. In the Technical Memorandum, NASA described how it evaluated two separate approaches to the cleanup: (1) centralized treatment, referring to using the location of the four City of Pasadena Monk Hill Subarea drinking water wells, and (2) on-facility extraction and reinjection, referring to the installation of new extraction and injection wells just inside the JPL fence line and reinjecting the treated water back into the aquifer near the southern portion of the JPL facility.

While both of these alternatives would remove the target chemicals in the mid-plume area, they are not equally effective in restoring the aquifer. Use of centralized treatment at the four City of Pasadena Monk Hill Subarea wells restores the use of the aquifer much more rapidly and would result in these wells being available for use by the local drinking water suppliers once the treatment facility is constructed and permitted.

3.10.2 Outside Consultants

NASA received a comment expressing a desire for NASA and the City of Pasadena to use outside consultants to maintain objectivity as the project moves forward.

NASA Response:

Outside consultants are and have been used for various aspects of the project, including groundwater monitoring, well maintenance, etc. In addition, several regulatory agencies, including the U.S. EPA, the California Department of Toxic Substances Control, and the Regional Water Quality Control Board, have legal authority and responsibility to oversee and monitor all work related to NASA's groundwater clean up efforts including the OU-3 response action. The California Department of Health Services also plays a role relative to any treated groundwater that LAWC and the City of Pasadena might provide as drinking water to the public.

3.10.3 NASA as the Lead Agency

An individual expressed dissatisfaction with NASA functioning as the lead agency in facilitating the cleanup program at JPL, asserting that this situation presented a conflict of interest. The individual also asserted that NASA should disclose any conflicts of interest in the selection of the site for the preferred alternative and noted that NASA's interests may be in conflict with the inhabitants of Altadena and Pasadena.

NASA Response:

The JPL facility is owned by the United States federal government. NASA is the federal executive agency with responsibility for JPL, including responsibility for all CERCLA cleanup actions related to NASA-controlled facilities. In 1992, NASA entered into a legally binding and enforceable Federal Facilities Agreement with the U.S. EPA, the California Department of Toxic Substance Control, and the Los Angeles Regional Water Quality Control Board. The Federal Facilities Agreement directs how these four agencies work together to develop and implement a cleanup program at NASA's JPL facility pursuant to CERCLA. The Federal Facilities Agreement for NASA's JPL facility stipulates that NASA is the lead agency for CERCLA cleanup activities related to JPL.

Conflict of interest is one aspect of public-sector ethics that NASA takes seriously. Executive branch employees hold their positions as a public trust and the American people have a right to expect that all employees will place loyalty to the Constitution, laws, regulations, and ethical principles above private gain. Employees fulfill that trust by adhering to general principles of ethical conduct, as well as specific ethical standards. The manner in which NASA administers its CERCLA program at JPL is no different. In addition, NASA consults with a variety of outside consultants to ensure the ethical and technical soundness of all aspects of NASA's CERLCA program at JPL. Moreover, all activities and decisions regarding the investigation and cleanup of the JPL CERLCA site are purposely reviewed and overseen by the U.S. EPA and State agencies. The California Department of Health Services also provides regulatory oversight and technical input for the LAWC and City treatment systems, as they is responsible for regulating drinking water. These state and federal agencies review and approve all project-related documentation issued by NASA and help ensure the ethical and technical soundness of all aspects of NASA's CERLCA program at JPL.

Finally, no NASA employee or any NASA consultant has personal conflicts of interest in the selection of the Windsor Reservoir site. NASA employees are prohibited by a federal criminal statute from participating personally and substantially in any matter that will affect their own financial interests. NASA holds its consultants to a similar standard.

3.10.4 Source Area Soil Cleanup Activities

NASA received a comment questioning the measures that were being taken to address chemicals in source area soil (OU-2).

NASA Response:

Soil located within the JPL fence line containing VOCs associated with past waste disposal practices has been effectively treated using a technology called soil vapor extraction (SVE) which removes chemicals over time. VOCs are removed by vacuuming the air containing the VOCs from the soil. This air is then treated to remove the VOCs before it is discharged to the atmosphere. Over time, the soil becomes cleaner and cleaner, until the cleanup goals are finally met. NASA prepared a Record of Decision for this response action in 2002. This cleanup effort

has been successful and NASA is currently preparing a report that documents the completion of this component of the cleanup activities.

3.10.5 On-Facility Treatment of Perchlorate at JPL

NASA received one comment questioning what type of technology was used to remove perchlorate from the groundwater at JPL.

NASA Response:

Perchlorate is highly soluble in water. As water passes through the soil, the perchlorate dissolves into the groundwater. The groundwater is pumped to the JPL treatment facility. The JPL facility uses a biological treatment system to remove the perchlorate in groundwater. This technology uses bacteria that consume the perchlorate, thus removing it from the water. This system also uses granular activated carbon to remove VOCs. Once the water is treated, it is reinjected back into the ground; it is not used as drinking water.

3.10.6 Potential Side Effects of Chemicals in the Groundwater

One commenter expressed concern that the existence of bugs in their home was related to the chemicals in the groundwater underneath their home.

NASA Response:

There is no known way that the infestation at the home is related to the chemicals in the groundwater. Groundwater is present approximately 270 feet below ground surface and there is no relationship between the chemicals therein and the infestation described.

3.10.7 Compensation

One commenter asked about what compensation NASA was offering to the residents in the area.

NASA Response:

NASA is funding a treatment plant to clean up groundwater that contains chemicals from historic operations. This facility will be operated by the City of Pasadena and NASA will fund the City for both the construction costs and operation and maintenance of the facility. There is no other compensation involved in this project.

3.10.8 The Proposed Plan

One individual expressed displeasure with the Proposed Plan stating that it was inadequate in summarizing the Remedial Response and public health issues. The individual also stated that NASA was employing propaganda techniques to "sell" the preferred alternative stated in the Proposed Plan.

NASA Response:

NASA respectfully disagrees. The Proposed Plan was written based on detailed guidance issued by the U.S. EPA as well as on the nine criteria for evaluating alternatives required by the National Oil and Hazardous Substances Contingency Plan. The criteria include: Overall Protection of Human Health and the Environment, Compliance with Applicable or Relevant and Appropriate Requirements (ARARs), Long-Term Effectiveness and Permanence, Reduction of Toxicity, Mobility, or Volume of Contaminants, Short-Term Effectiveness, Implementability, Cost, State Acceptance, and Community Acceptance. In addition to the Proposed Plan, NASA also issued a supplemental Technical Memorandum that explicitly evaluated each of the alternatives.

NASA has encouraged public discourse by holding public meetings, giving the public the opportunity to speak and carefully consider comments. NASA acknowledges that while the preferred alternative is protective of public health and the environment, not all members of the public will agree with NASA's decision. Nonetheless, NASA remains committed to keeping the public aware of and informed about its cleanup activities. NASA's Manager for Community Involvement, Merrilee Fellows, and Remedial Project Manager, Steve Slaten, have made and will continue to make themselves available to meet with members of the public to discuss questions and concerns associated with various aspects of the cleanup. Please contact Merrilee Fellows at 818-393-0754 or via e-mail at mfellows@nasa.gov.

3.10.9 Opposition to Remedial Action

One individual objected to the Preferred Alternative based on cost, citing that the levels of perchlorate in the water are not high enough for action.

NASA Response:

NASA is required by CERLCA to clean up the groundwater according to state and federal standards. Some chemicals in the groundwater currently exceed these standards.

3.10.10 Working Together to Clean Up the Groundwater

One individual acknowledged the negative feelings that the community had about the proposed location for treatment. He also acknowledged and emphasized the seriousness of the problem with the groundwater and while recognizing the legitimacy of the residents' comments he pleaded that all parties involved work together so that the cleanup could progress forward as needed to restore the water resources.

NASA Response:

NASA takes responsibility for the chemicals in the groundwater beneath and adjacent to JPL. NASA agrees it is a complex problem that needs to be addressed, and is committed to working together with the community toward a resolution. The Windsor Reservoir site was determined to be the most appropriate location for the treatment facility in terms of protection of health and the

human environment, long-term and short-term effectiveness, timely implementability as well as meeting the other evaluation criteria listed in Section 3.2 of this Summary. NASA also commits to continue to communicate and work with the community as NASA progresses with its clean up.

3.10.11 Source Area Treatment System

NASA received one comment seeking clarification about the on-facility, source area treatment system at JPL, including what type of technology was being used to remove perchlorate from the groundwater underneath JPL.

NASA Response:

The treatment plant located on the premises at JPL treats deep groundwater in an 8-acre area directly beneath JPL. This area consists of the highest concentrations of perchlorate and VOCs in groundwater, which serves as a source of chemicals to groundwater in the Monk Hill Subarea. Groundwater is pumped up to the system, which uses a biological treatment process called a fluidized bed reactor to remove the perchlorate. This technology uses bacteria that consume the perchlorate, thus removing it from the groundwater. This system also uses granular activated carbon to remove VOCs. The treated groundwater is pumped into reinjection wells located upgradient from the system. The purpose of the system is two-fold: first, it treats the groundwater with the highest concentration of VOCs and perchlorate, and second, it prevents migration of these chemicals to the City of Pasadena and LAWC drinking water production wells.

3.10.12 The City of Pasadena

One individual asked why the City of Pasadena was involved in the project.

NASA Response:

The City owns the four productions wells located within the Monk Hill Subarea, in the area where chemicals from JPL have migrated. NASA has been funding cleanup activities in this area for over a decade. The construction of the City of Pasadena treatment system in the Monk Hill Subarea is one component of NASA's comprehensive effort to clean up groundwater beneath and adjacent to JPL. NASA is funding the City to lease and operate the treatment system; therefore, their involvement in the process is very important.

3.10.13 Levels of Treatment

One individual asked what effluent levels of perchlorate are expected and/or required at the proposed treatment plant.

NASA Response:

CERLCA requires that the more stringent of a federal or California requirement be met before a remedy can be implemented, which includes specifying the treatment levels that must be achieved. These are enforceable concentrations and such levels must be achieved. The type of system that will be used is expected to remove the chemicals to below those of the current State Public Health Goal. The U.S. EPA and the State agencies will all continue to oversee the treatment system to ensure that the state and federal drinking water requirements are met at a minimum as required by CERCLA.

4.0: REFERENCES

National Aeronautics and Space Administration (NASA). 2004. *Action Memorandum For the Lincoln Avenue Water Company (LAWC), Altadena, California Associated with Groundwater Cleanup at the National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, California*. August.

National Aeronautics and Space Administration (NASA). 2006. *National Aeronautics and Space Administration Environmental Cleanup Program Community Involvement Plan (Second Update) for the CERCLA Site at the Jet Propulsion Laboratory*. August.